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# QUARTERLY

OF THE

# National Fire Protection Association

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87 MILK STREET, BOSTON, MASS.

EDITED BY THE SECRETARY

# National Fire Protection Association.

**Executive Office, 87 Milk Street, Boston, Mass.**

## Active Members.

January 1, 1916.

American Institute of Architects.
American Institute of Consulting Engineers
American Institute of Electrical Engineers.
American Society of Heating and Ventilating Engineers.
American Institute of Mining Engineers.
American Concrete Institute.
American Gas Institute.
American Electric Railway Association.
American Warehousemen's Association.
Arkansas Actuarial Bureau.
Arkansas Fire Protection Association
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Iowa State Fire Prevention Association.
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Kentucky State Fire Prevention Association.
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Massachusetts Mutual Fire Insurance Union.
Michigan Inspection Bureau.
Michigan State Fire Prevention Association.
Millers' National Federation.
Mississippi Inspection and Advisory Rating Company.
Mississippi Society for the Prevention of Fires.
Missouri Inspection Bureau.
Mutual Fire Prevention Bureau.
National Association of Building Owners and Managers.
National Association of Credit Men.
National Association of Electrical Inspectors.
National Association of Insurance Agents, The
National Association of Manufacturers of United States.
National Assn. of Master Gravel and Slag Roofers of America
National Automatic Sprinkler Association.
National Board of Fire Underwriters.
National Commercial Gas Association.
National Convention of Insurance Commissioners.
National Electrical Contractors' Association.
National Electric Light Association.
National Founders' Association.
National Gas Engine Association.
National Implement and Vehicle Association
National Lumber Manufacturers' Association.
National Paint, Oil and Varnish Association.
National Petroleum Association.
National Wholesale Druggists' Association.
National Wholesale Grocers' Association.
Nebraska Inspection Bureau.
New Brunswick Board of Fire Underwriters.
New England Bureau of United Inspection.
New England Insurance Exchange.
New Hampshire Board of Fire Underwriters.
New Jersey Schedule Rating Expert's Office.
New York Board of Fire Underwriters.
New York Fire Insurance Exchange.
Newfoundland Board of Fire Underwriters.
North Carolina Fire Prevention Association.
Nova Scotia Board of Fire Underwriters.
Ohio Inspection Bureau.
Ohio State Fire Prevention Association.
Oklahoma Inspection Bureau.
Philadelphia Fire Underwriters' Association
Philadelphia Suburban Underwriters' Association.
Rocky Mountain Fire Underwriters' Association.
South Carolina State Fire Prevention Association.
South Dakota State Fire Prevention Association
Southern Cypress Manufacturers' Association.
South-Eastern Underwriters' Association.
State Fire Insurance Commission of Texas.
St. Louis Fire Prevention Bureau.
Suburban Fire Insurance Exchange.
Tennessee Fire Prevention Association.
Tennessee Inspection Bureau.
Texas Fire Prevention Association.
The Union.
Underwriters' Association of the District of Columbia.
Underwriters' Assn. of the Middle Department.
Underwriters' Association of New York State.
Underwriters' Bureau of Middle and Southern States.
Underwriters' Bureau of New England.
Underwriters' Laboratories, Inc.
Vancouver Island Fire Underwriters' Association.
Water Works Manufacturers Association.
Western Actuarial Bureau (Fire).
Western Canada Fire Underwriters' Association.
Western Factory Insurance Association
Western Sprinklered Risk Association.
West Virginia Inspection Bureau.
West Virginia State Fire Prevention Association.
Wisconsin Inspection Bureau.
Wisconsin State Fire Prevention Association.

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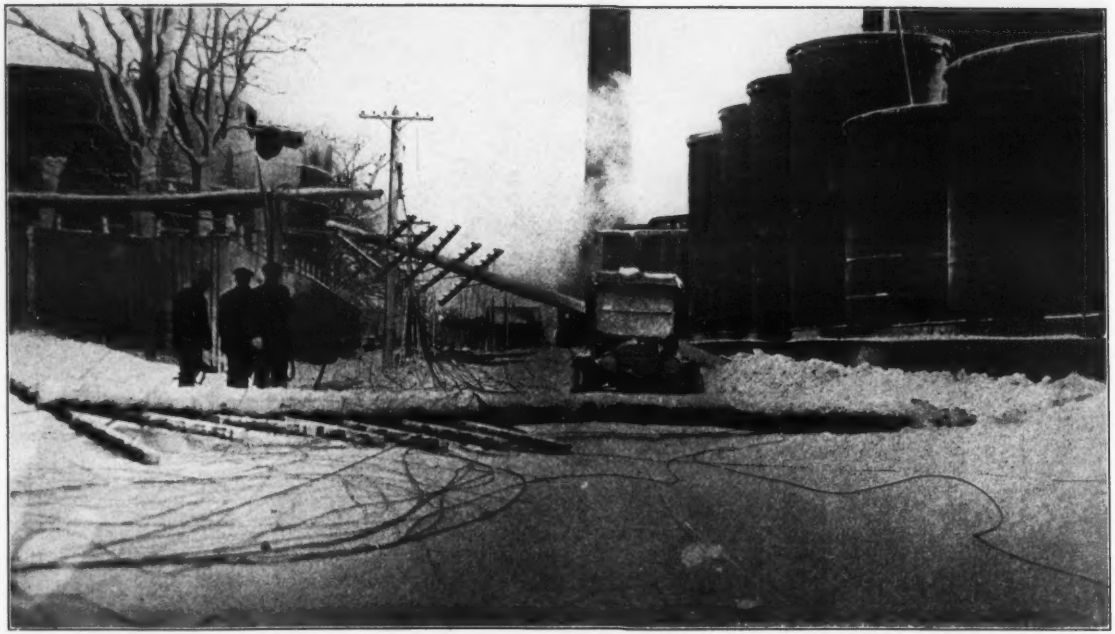
*Reports on fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.*



*Courtesy of Municipal Engineers, N. Y.*

**Winter Damage to Fire Alarm Wires. An eloquent argument for installing city signal circuits in underground conduits.**

**A CARELESS TABBY**

The cause of the fire was said to be the tipping over of a lamp, which had been left burning during the night by the family cat. (*From the Valparaiso, Ind., Messenger.*)

# The Quarterly

Vol. 9 January, 1916. No. 3.

**The Proposed Fire Appliance Exposition.** A proposition made by competent and reliable persons to conduct for a series of years an exposition of fire appliances under the auspices of the N. F. P. A. at the time of our annual meetings was recently considered by the officers of the Association at a special conference and declined. The officers had before them at this conference the written opinions of the majority of the executives and the written opinions of some thirty of our associate members interested commercially in fire appliances to whom the proposition had been submitted for comment. While these opinions were conflicting, the preponderance of feeling thus expressed was unfavorable to the enterprise, and the officers themselves were almost unanimously against the association's identifying itself with anything of the sort, even though no financial responsibility were involved. While such an exposition in itself appeared desirable, and its educational value to the public was quite obvious, the perplexing questions of policy involved influenced the officers in their adverse decision. The proposition as made involved so far as the association was concerned only its good will and the use of its name; all risks and labor to be borne by the proponents. It was difficult, however, in the opinion of the officers to draw any lines of policy between abstinence from all direct connection with the proposed enterprise and assuming the full conduct of it. Any divided responsibility might lead to embarrassments on both sides. In an exposition held under the auspices of the N. F. P. A. it would be natural for persons inspecting the exhibits to infer, at least, that everything displayed enjoyed the favor of the association. Were this actually the case the choosing of the exhibits would be an important and responsible function, one which could hardly be left either to the managers of the exposition or the exhibitors themselves. It was not clear how any limitation could reasonably be put upon the character of the material or appliance exhibited, provided it had a bearing upon the fire prevention problem and the exhibitor was willing to pay for space and subscribe to the regulations of the exposition.

In declining the proposition the officers let it be known that should the proponents desire to undertake to conduct such an exposition as their own private enterprise at the time of our annual meetings the N. F. P. A. attitude toward the same would undoubtedly be friendly provided the announcements of the managers made clear the fact that the undertaking was wholly their own.

* * * * *

**Grading Cities and Towns in Fire Defense.** The National Board of Fire Underwriters has added to its already notable achievements the compilation of a proposed standard schedule for grading the cities and towns of the country in respect to their fire defenses and physical conditions. This proposed schedule is not promulgated for the present or immediate use of rating organizations although such use is to be its final destination. The National Board desires that it shall be thoroughly tested by application to a large number of cities and towns having varying conditions as to all the points of grading contemplated by the schedule. Possible injustice in its application may thus be avoided. The grading schedule is based upon the plan of assigning to the various features of fire defense found in cities of the United States, points of deficiency depending upon the extent of variance from standards formulated from a study of conditions in more than 300 cities; the natural and structural conditions which increase the general hazard of cities, and the lack of laws or of their enforcement for the control of unsatisfactory conditions, are graded in the same way. The sum of the maximum points of deficiency (5,000) is divided in accordance with the relative values of the features of water supply, fire department, fire alarm, police, building laws, explosives and inflammables, electricity, and natural and structural conditions. The details of these various items and the points of demerit written against them have been worked out with great diligence by the engineers of the National Board, and the proposed schedule will be an object of interesting study to those who have been seeking a basis for comparing the virtues of fire defense of cities of the same size, experiencing the same climatic conditions.

* * * * *

**The Fire Waste Survey of Canada.** The Dominion of Canada is undertaking what is probably the most comprehensive inquiry into the subject of the fire waste ever attempted by any government. Mr. James White, Assistant to Chairman and Deputy Head of the Commission of Conservation (member, Executive committe, N. F. P. A.) advises us of this survey now being conducted for the Commission by Mr. J. Grove Smith, and which is to be reported to the government by the Commission in February. The wide scope of this inquiry may be realized when it is known that the Commission plans to present not only a complete record of the causes and extent of fire losses in the Dominion, but a survey of the means at present employed in fire control including a resumé of all provincial and municipal laws affecting

fire. Upon the facts thus presented the Commission hopes to establish a good case for a Fire Marshal law in each Province, a statutory minimum building code for the Dominion, and compulsory standards for public fire protection, as well as to stimulate the organization of public opinion on the subject of fire protection by means of local associations or committees. The information is being gathered upon carefully prepared blanks by which the mayor or reeve is expected to report certain items and the fire chief others. Many items in which the members of the N. F. P. A. in both Canada and the United States are very much interested will be available when the survey is completed. For example, outside of the inquiries covering the nature of building construction, fire department equipment, etc., such questions are asked as: Are shingle roofs permitted? Is there fire prevention inspection? Are there lumber yards in the business section? What is the diameter and thread of your hose coupling? Have you ever considered adopting the Standard coupling?

The Dominion is to be congratulated upon the fact that the proportions of the fire waste have sufficiently impressed the Government as to induce it to order such an inquiry as this, and it is lucky in the possession of a deputy head of its Commission of Conservation sufficiently conversant with the subject to guarantee an investigation that is not merely perfunctory. The government of the United States might very well follow the lead of its enterprising neighbor in this matter.

* * * * *

**Underwriters' Laboratories and the Bureau of Standards, U. S.**

The value of the agreement of the Bureau of Standards, U. S. to investigate and pass upon claims made by manufacturers or others appealing from rulings of the Underwriters' Laboratories respecting the merits of fire appliances or materials submitted to the Laboratories, has been recently tested.

The case was that of the Economy Fuse and Manufacturing Company, well known to our members who follow the work of our Electrical Committee, and the decision rendered by the Bureau of Standards was in favor of the Laboratories. The report of the Bureau sets forth in full the evidence upon which the finding is based and covers 550 pages.

Notice of appeal in this case was filed at Washington on May 17, 1915. A preliminary hearing was held in Chicago on May 27, and, pursuant to notice issued June 10, a public hearing was held in Washington on July 8.

Experts of the Bureau conducted exhaustive tests at Washington, Boston and Chicago, investigated performance of the devices in service at New York, New Haven, Philadelphia, Baltimore, Pittsburg, Cincinnati, Cleveland and other cities, and, following requests received from manufacturers, twice extended the time fixed for filing evidence. Working under these conditions, the Bureau handed down its exhaustive report and decision under date of December 14, less than seven months after the first notice was filed at Washington. The case presented very unusual com-

plications, which would have undoubtedly involved excessive costs and several years of litigation, if adjudication had been attempted through the machinery of State or Federal courts. The expert judges of the National Bureau of Standards have demonstrated their ability to render a new and very valuable service to the public.

The Laboratories were represented by W. H. Merrill, Manager, Dana Pierce, Electrical Engineer, and Darrell S. Boyd, Attorney. The Economy Fuse & Manufacturing Company was represented by A. L. Eustis, President, R. J. Foote, Counsel, H. M. Huxley, Patent Counsel, H. E. Clifford, Electrical Expert, and A. B. Mallory, Chief Engineer.

Representatives of the Bureau of Standards conducting the investigation and presiding at the hearings were Dr. S. W. Stratton, Director, Dr. E. B. Rosa, Chief Physicist, W. J. Canada, Electrical Engineer, Burton McCollum, Electrical Engineer, H. B. Brooks, Associate Physicist, and T. W. Glading, Associate Electrical Engineer.

* * * * *

**Closed Sprinkler Valves.**

Regarding closed sprinkler valves, J. P. Gray, president of the Boston Manufacturers' Mutual Insurance Company, says:

"Fires have occurred recently in two of our plants, and in each case the valve controlling the sprinkler equipment in the building where the fire occurred was closed. In the first case it was reported to be open at two o'clock in the afternoon. At nine in the evening, when the fire occurred. it was closed. The result was a loss of about a quarter of a million dollars, because it was assumed that the valve was open. In the second case there was no indicator on the valve, and the master mechanic considered it, and reported it, as open, when it was actually closed. In this case, due to the very efficient handling of the fire by the mill fire brigade, the loss was kept so small that no claim was made.

"When the system of self-inspection of valves was first inaugurated the result was a largely decreased number of valves found closed by our inspectors. Of late this number has been increasing to an alarming extent, indicating that because of the routine nature of the work the inspectors have failed to actually note the condition of the valves. We have just received word from the management of one of our large corporations that they have tested seven of their inspectors by deliberately closing a valve a few minutes previous to the inspection. Five of the seven inspectors passed by the closed valve and reported it open. This indicates an alarming condition of affairs.

"In view of these conditions it is again advised that the inspector be changed frequently. It is also advised that whenever a fire occurs in a plant it be the duty of some responsible individual to immediately inspect the valve controlling the sprinkler equipment in the building where the fire is, and also to satisfy himself that the water is actually discharging from the sprinkler equipment. If this had been done in the case mentioned

above, the loss, instead of being about a quarter of a million dollars, would have amounted to little or nothing. It would be well to have a member of the fire brigade trained especially for this purpose. Our members have expended a large amount of money for sprinkler equipments, and the only way that they can be sure of getting the benefit of same is to be certain that the equipment is at all times in an operative condition."

* * * * *

**A Fire Prevention Day, Fire Loss.** An interesting incident in connection with a fire at Dayton, Ohio, is reported by one of our members. The fire occurred on Fire Prevention Day, October 9th, at the time when practically the entire fire and police departments were attending the Field Day exercises and taking part in the exhibits at the County Fair grounds located about one mile from the scene of the fire. The fire originated on the roof of a residence and owing to the delay in the response of the department involved a loss of about $2,000 with considerable damage to adjoining residences. After the fire was discovered and the alarm turned in, the fire department had to make the run from the fair grounds. Our correspondent states that the incident practically broke up the Fire Prevention Day celebration. The result of the absence of the department from its headquarters caused the largest dwelling house loss which has occurred in Dayton since the losses at the time of the flood in 1913. It is obvious that when fire departments co-operate in public celebrations care should be taken that the city shall not be unprotected. This is the first fire loss to be reported as due to Fire Prevention Day exercises.

* * * * *

**Power of Fire Marshal to Tear Down Buildings.** Power to enforce his orders by tearing down dilapidated buildings on the failure of owners to comply with tear-down orders was invoked by the fire marshal recently for the first time in New Castle, Ind., when his operatives removed a group of old and dilapidated buildings. Following the issuance of the order of the fire marshal, the owner appealed to the Henry County Circuit Court for a review of the order which directed him to tear down his buildings. The court affirmed the order of the fire marshal on appeal and fixed the date for compliance as April 24, 1915. The owner having failed to comply with the order as affirmed by the court on that date, his buildings were razed by the department. The Indiana statutes provide that the expense of such removal shall be charged to the owner. His failure to pay the costs within thirty days results in adding a penalty of 25 per cent to the costs. The entire amount is then placed on the tax duplicate and collected as taxes, becoming a lien on the real estate on which the buildings stood.

# Members' Activities.

President Charles E. Meek was the speaker on fire prevention at the third Pennsylvania Welfare, Efficiency and Engineering Conference held in the Hall of Representatives at the State Capitol in Harrisburg, Pa., on November 16th. This conference was called for the purpose of familiarizing the public and the various departments of the State Government with the work of the separate departments which have to do in a responsible manner with State engineering projects, natural resources and industries.

On the evening of December 6th, President Meek addressed the Men's Club of the Dutch Reformed Church of Bayonne, New Jersey. The meeting was well attended and interest shown especially in the president's remarks on the hazards of the wooden shingle which is the prevailing roof-covering in Bayonne. An unfortunate accident happened in a run to a fire which occurred while Mr. Meek was speaking. When the alarm came in, Assistant Chief Lewis S. Bonney jumped into the car belonging to Commissioner of Safety, Henry Wilson, and started from headquarters at top speed. He turned into the Hudson County Boulevard and was going fifty miles an hour at Fourteenth Street. The car hit a truck, crashed into a tree, overturned, and pinned Bonney under it. Other motorists got Bonney from under the car, and sent for a doctor who said the Chief was dead.

Bonney was 48 years old and married. He had been chief of the old volunteer fire department and became Assistant Chief when the paid department was put in. The fire was of no consequence.

* * * * *

Secretary Franklin H. Wentworth spoke at Columbus, Ohio, on December 6th, at a dinner given by the Credit Men to which representatives of all the commercial bodies of Columbus were invited. On December 7th, he spoke at the dinner of the Pittsburgh Association of Credit Men given under the auspices of the Fire Prevention Committee of which Mr. D. C. Shaw is chairman. Mr. Shaw is a devoted fire-preventionist to whom we owe the co-operation of the National Wholesale Grocers' Association in our work. A report of this meeting taken from the *New York Journal of Commerce* is printed on another page. On December 9th, Secretary Wentworth was the guest of the American Face Brick Association at its annual banquet at Hotel Chamberlin, Old Point Comfort, Va. It was a brilliant affair attended by the members and their ladies. Mr. Wentworth said, in part:

One factor which emerges from a large view of the future of building construction is the certain influence of the maturity of the country upon it. Europe's stability in

buildings, which so impresses the traveler from America, is derived from the fact of this maturity. We in America have been content to build for one generation because of the uncertainty of our zones of population and the developments which affect them. We all remember those early schemes of the land speculators and railroad builders of the West by which terminals were shifted and embryo cities left gaunt and deserted upon the prairies, bankrupting the betrayed individuals whose faith in the permanence of the terminal had led them to construct decent buildings. That period has passed and the class of eminent financiers who made it historic now operate in Rock Island, New Haven and other properties nearer home.

This evolution in business ethics has shifted the support of these gentlemen from the city builder to the widow and orphan, and thus eliminated their direct influence from the building problem we are discussing to-night. What I wish to say is that America is now sufficiently settled, and the character of our cities sufficiently established to invite a permanency of investment which the uncertainty of our early years of national existence did not encourage. Even in our private residences this influence may be counted on increasingly to manifest itself as the stability of our cities is demonstrated. American families will come to occupy the same home for generations as European families now do, and will build with that thought and intention. Not only will our family life and traditions be immeasurably enriched by such building, but the beauty and dignity of our cities will be vastly enhanced. In the benefits of this coming era your industry is bound to share and it is my opinion that you well deserve to share in them, because of the very great contribution you have made to the building art. To him who has eyes to see there appear to be few modern developments in building materials along the road to beauty that surpass those of the burnt clay industries. I have seen face brick of American manufacture that in delicacy of texture and depth and harmony of color rivals the beauty of a Persian rug. The qualities of beauty and permanency your industry contributes to the building art should guarantee your enduring success.

* * * * *

The New York Chapter N. F. P. A. held its December meeting on the 13th, at the City Club, 55 West 44th Street, with a member of the association, Mr. William Guerin, ex-chief of the Fire Prevention Bureau, as speaker. Mr. Guerin's subject was "The work of the fire prevention expert and its value to the municipality." He said in part: —

To-day the progressive chief of a fire department feels the need of fire prevention work to be as great as that of fire extinguishment, for preventing fires means fewer fires, saving of lives, less interruption of business and fewer homes destroyed.

In New York City during the year 1914, more than 8,000 fires occurred, every one of them preventable by using a little care.

Carefulness is a moral quality, and you can never legislate it into the individual — you must teach it to him. Of course we can have legislation that will punish the careless one, but we don't want to wait until every careless act has been punished to bring about our reform of the fire waste.

I dwell strongly on the matter of education for several reasons, chief of which is that a careful body of men can operate a powder mill in a frame building for an indefinite period of time without a fire occurring, if sufficient care is exercised, while on the other hand in the year 1911 in New York City 146 lives were lost by fire in a building admitted to be of fireproof construction except for the wooden floors and trim, neither of which contributed materially to the origin or spread of the fire. The building had adequate standpipes and hose, and the business carried on was women's shirtwaists. This fire, like thousands of others, was caused by an act of carelessness, throwing away a lighted cigarette.

In New York City a record has been kept monthly, and consolidated each year, showing in what class of buildings fires occurred, and at what point in the building the

fire started. This report, both monthly and yearly, shows that more than sixty per cent. of all fires occur in the homes of the people.

We do not hesitate to enter a store, a factory or hotel and order the removal of rubbish, the safeguarding of a dangerous condition, or the ceasing of a dangerous practice, because these places are "affected with a public interest" and the police power of the State unhesitatingly compels obedience.

But in the homes of the people we have a different proposition. We have inherited an Anglo-Saxon civilization based on personal liberty and the sacredness of a man's home, and the State pauses on its threshold and only crosses it without permission when a felony has been committed or pestilence is within. Therefore, the people in their homes may only be reached by education.

For forty-seven years the fire loss of New York City showed a steady and gradual increase until the year 1911, when it totaled $12,500,000. In two years (1913) the fire loss had been brought down to $7,400,000, and there were 2,675 fires less in 1913 than there were in 1912.

This demonstrates that, rightly directed, fire prevention can prevent fires.

* * * * *

Mr. James E. Latta who spoke so interestingly on the work of Underwriters' Laboratories at the N. F. P. A. luncheon at Hotel Astor, last May, was the speaker selected by the Insurance Institute of Toronto to open its season's lecture course on October 29th, at Convocation Hall. Our Canadian friends were much pleased by their more intimate knowledge of the Laboratories afforded by the motion pictures displayed by Mr. Latta. At the November meeting of the Atlanta, Ga., Affiliated Technical Societies, Mr. Latta was the speaker, his appearance having been arranged by Mr. A. M. Schoen of the N. F. P. A. Executive Committee who is an officer of the Atlanta body. On the 18th and 19th of January, Mr. Latta is to speak in Birmingham and Montgomery, Alabama, Mr. Schoen being with him at those points. Local conditions in these cities make Mr. Latta's visit a timely one.

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The Fire Underwriters' Inspection Bureau, San Francisco, F. H. Porter, Manager, has issued some interesting diagrams of the tunnel connections between the basements and sub-basements of many of the principal buildings in Los Angeles. Interlocking heating plants are popular in that city, and Mr. Porter shows how in the event of fire, water might flow from some of these buildings to the others.

* * * * *

Fire Prevention education in schools by means of essays written for prizes seems to be growing in popularity among our members active in fire prevention work.

The Sioux City (Iowa) Association of Credit Men has offered prizes of $10 and $5 for an essay on either "Fire Protection as an Economic Factor in the United States," or "The Practical and Personal Application of Fire Prevention." The contest is open to all seniors and juniors in the high school.

First prize in the fire prevention essay contest held recently by the Indiana state fire marshal has been awarded to Gordon Clevenger of the Greensburg, Ind., high school, and second prize to Heiman Blatt of the Evansville, Ind., high school. First place pays the winner $15, the second, receiving $10. The judges gave honorable mention to the manuscripts of several other pupils in different parts of the state.

* * * * *

A fire prevention meeting was held in December by the Grand Rapids, Mich., Credit Men's Association. H. P. Weaver of the Independence Inspection Bureau, Chicago Office, a member of the N. F. P. A. committee on Manufacturing Risks and Special Hazards, gave a talk, illustrated by lantern slides, on the results of carelessness in building construction and in allowing rubbish to accumulate.

* * * * *

Past-president Robert D. Kohn addressed the mid-year conference of the Real Estate Association of the State of New York at Hotel McAlpin, New York City on January 7th. Mr. Kohn never makes a perfunctory speech. His remarks on this occasion went straight to the goal and the real estate men who listened to him will make no mistake if they carefully consider the suggestions he made. The principal matter in Mr. Kohn's speech is printed on another page.

* * * * *

The present wide-spread interest in ammunition factories makes the article by J. Albert Robinson in this issue timely and serviceable. The elusive forms and unexpected places in which these hazards now appear are interestingly suggested by Mr. Robinson whose painstaking research and diligence in the production of this paper must challenge the admiration of his fellow members of the N. F. P. A.

* * * * *

Mr. C. W. Dawson, architect, one of our members in Muskogee, Oklahoma, is keenly interested in the proposed motion picture "The Fire Demon", in preparing the scenario of which our association assisted, and of which when it is ready the N. F. P. A. is to purchase a reel. Mr. Dawson has written letters to the Rotary Clubs urging their co-operation in the display of this film, and is also urging the International Association of Rotary Clubs to become an active member of the N. F. P. A. and share in the work of fire prevention.

* * * * *

At the Second Pan-American Scientific Congress held in Washington, D. C., in December, the official delegates from the N. F. P. A. were Mr. Powell Evans, of Philadelphia, member of our Executive Committee, and Hon. Charles F. Nesbit, Superintendent of Insurance of the District of Columbia. Mr. Nesbit is planning to interest Congress in a law for the District fixing individual liability for fire losses due to negligence.

Mr. E. P. Heaton of Toronto, former member of our Executive Committee, representing our active member the Canadian Manufacturers Association, has been appointed by the Ontario Government fire marshal for that Province.

Legislation was passed in 1914 providing for the creation of this position, and according to the act the duties will include the investigation of the cause, origin, and circumstances of all fires occurring in the Province, the gathering of records and statistics as to fire waste, and the adoption of whatever measures may be considered necessary towards lessening fire dangers. The act makes provision, if necessary, for the appointment of Deputy Marshals in centres of importance throughout Ontario.

Mr. Heaton's friends in the N. F. P. A. will be glad to learn of his re-entry into fire prevention work as a public official.

* * * * *

Past-president Robert D. Kohn, New York architect, has been appointed special representative of the N. F. P. A. upon an advisory committee of the Bureau of Standards, U. S., formed for the purpose of outlining a program of investigation of the fire-resistive qualities of various structural materials used in wall construction. The Bureau of Standards is now constructing a panel-testing furnace for these tests.

* * * * *

Chairman C. L. Scofield, of the Committee on Automatic Sprinklers, has submitted to his committee a proposed uniform blank for testing dry pipe systems in cold storage warehouses, the accompanying appendix of which further emphasizes Mr. Scofield's diligence and care in handling his portfolio. He proposes to call a meeting of his committee for early in March and is arranging with Chairman W. O. Teague of the Committee on Standardization of Pipe and Pipe Fittings for a meeting of Mr. Teague's committee at the same time, as certain members are on both committees.

* * * * *

Engineer L. T. Kane, Engine Company 31, Los Angeles, Cal., Fire Department, reports that a course in fire protection engineering has been added to the classes of the Polytechnic Evening High School of Los Angeles and that nearly one hundred firemen have been enrolled. This looks like a good start toward ending the confusions in fire department policies that have been reported from the city of the Angels during the past year.

* * * * *

Several Boston members, R. Clipston Sturgis, Frank Irving Cooper, Gorham Dana, Secretary Wentworth and John A. O'Keefe are serving upon a Massachusetts State committee organized at a Faneuil Hall meeting following the Peabody Roman Catholic School holocaust for the purpose of preparing suggestions for safeguarding the public schools of the state already erected and in use. Fire Prevention Commissioner O'Keefe is Chairman of the committee, and is about to promulgate the committee's suggestions.

Mr. D. A. Fisher, a Memphis, Tenn., member, writes as follows:

In looking over some old records a few months since, I ran across the enclosed memorandum of two fires, which even at this late date are of considerable interest in showing the advantages of sprinkler protection. You will note the buildings were practically of the same area and construction, were located diagonally across the Street from each other, and the fires occurred just a month apart.

Following is the matter referred to:

**B. Lowenstein & Bros., Wholesale, Main and Jefferson:** Fire occurred at 4.10 A. M., March 22, 1906, on the second floor near the passenger elevator. Confined to place of origin by sprinklers and no claim made on building or contents.

This building is located on the Southeast corner of Main and Jefferson, 7 floors, area 75′ x 150′ — 78,550 square feet. Annex, 9 floors, area 65′ x 75′ — 43,875 square feet.

**Equitable Building, Main and Jefferson:** Fire occurred at 9.05 P.M., February 21, 1906, on second floor near elevator. Building loss $43,301.13. Contents loss $15,404.32.

This building is located on the Northwest corner of Main and Jefferson, 7 floors, area 75′ x 100′ — 52,500 square feet less 50′ x 20′, 6 floors, 6000 square feet. Net area 46,500 square feet.

It will be noted that the Lowenstein building was sprinklered and that the Equitable building was not. Mr. Fisher's memorandum is luminously suggestive.

* * * * *

Chairman W. O. Teague of the Boston Committee arranged a very pleasant informal dinner at the Boston City Club on Friday, January 7th, in honor of Mr. D. Knickerbacker Boyd of Philadelphia, former secretary of the American Institute of Architects and member of the N. F. P. A. Committee on Public Information. Mr. Boyd has made a business connection with Sweets' Catalogue service which is calculated to enhance considerably the value of that service to architects.

* * * * *

An exceedingly useful book has just been published by the Department of Public Safety of Philadelphia, entitled Information for Fire-fighters. It is intended to give the officers and men of the fire department a proper perspective of this branch of the city service and contains interesting chapters on the early history of the department, the Bureau of Fire and other bureaus which assist in fire-fighting, the customs and regulations of the Bureau of Fire, the privileges and duties of each rank, the training school for fire service, military drill and ceremonies, and advancement and suggestions. From this book any fireman may post himself regarding his own work and the work of his superiors, and get an idea of the teamwork possible to a well organized department. The preparation and publication of the book was financed by private subscription and it is not difficult to trace its origin to the public spirit of Powell Evans, of the Executive Committee of the N. F. P. A., to whose unusual talents and untiring energy the cause of fire prevention in Philadelphia is already so positively indebted.

The Railway Fire Protection Association, with which many of our railroad members are identified, held its second annual meeting at the Hotel La Salle, Chicago, on October 5, 6, 7, 1915. President F. H. Elmore of the Southern Railway Company, Washington, D. C., presided and emphasized the importance of the objects of the organization, especially the establishment of uniform standards for railroad fire prevention.

The Association offers all railroad men special opportunities for the interchange of ideas and experience with regard to such matters, and was formed in 1913 after an informal meeting of the railroad representatives who were in attendance at the annual convention of the National Fire Protection Association. The Association has adopted as a slogan, "Reduced fire losses means reduced operating expenses." The problem has been largely to arouse the interest of the operating departments of the railroads to the point where the full co-operation of the officers and employees might be secured. Pamphlets and circulars of various kinds based upon statistics have been distributed from time to time. This association has made very rapid progress and due to its efficient work and the appeal of its slogan has already secured the active support of many of the railroad executives.

Following are the names of its principal committees reporting at the Convention: Rules and Regulations for Prevention of Fires and Protection of Property; Fire Prevention and Protection in Terminal Classification and Storage Yards; Fire Prevention and Protection in Stations, Freight Depots and Warehouses; Cotton Hazards; Locomotive Sparks and Ash Pans; Railway and Forest Fires. The Association has decided to compile a standard book on railroad fire protection and prevention and for the construction of railroad buildings. It is hoped to have this work completed before the next annual meeting.

The good work which this association is doing will appeal to our members since it is very largely parallel to our own although limited to railroads and their problems.

The officers for 1915-1916 were all re-elected and are as follows: President, F. H. Elmore, Southern Railroad, Washington, D. C.; Vice President, Paul Hevener, Rock Island Lines, Chicago; Secretary-Treasurer, C. B. Edwards, Mobile and Ohio Railroad, Mobile, Alabama.

# The Real Estate Interests and Fire Prevention*

By Robert D. Kohn.

Past President of the National Fire Protection Association.

There is a very marked impression on the part of the public that the real estate men are opposed to modern fire prevention methods; or at any rate, that they are antagonistic to any proposed laws or ordinances that tend to increase the complication of construction in any way whatsoever. It is very generally believed that such opposition on the part of real estate men is due to their objection to any increase in the cost of construction, and the fear that such legislation when made retroactive will require expensive alterations to existing buildings. They are supposed to be particularly antagonistic to any proposal that is likely to take away the profitable margin on incomes on existing property through structural changes required by law. Only a few days ago some one said to me in all sincerity that real estate men after all did not care a rap about any civic question; they had no interest in anything except what they could make out of sales and leases and speculation.

Now as a matter of fact from what I have heard at some of your meetings I know that quite a different spirit is latent if not always obvious among your membership. Although I know that in many cases ill-considered laws have worked hardship on individual property owners, I believe none the less that the large majority of the real estate men of this State are fundamentally interested in securing safety to life and property by any practical means that can be proposed. I do not believe the real estate interests have always been represented by men of that type. Criticism has to a certain extent been justified by the unfortunate attitude which certain representatives of the real estate interests have on occasion taken when great calamities caused a sudden outburst of public indignation against the dangers that abound in miserable fire-traps. It is because I believe that you are in reality fundamentally in favor of what is right, and because I believe that your membership has such knowledge of actual conditions as could be made of the greatest possible value to the community that I urge you to put that information and that knowledge of practical affairs at the disposition of those who are working for progress in fire prevention and other safety work. I want to suggest two methods by which in my opinion the Real Estate Association of

*Extract from address before the Real Estate Association of the State of New York, January 7, 1916.

the State of New York can become a most valued force towards the betterment of conditions in this regard.

In the first place, I think your Association should declare itself not only in opposition to bad laws, but frankly and forcibly in favor of good laws and ordinances as they are presented for consideration. The real estate men ought not to let the public assume that they are always in opposition to anything that is proposed in the way of betterment. As a matter of fact the real estate interests cannot be in opposition to wise protective legislation, and yet that is what the public takes for granted to be the case. I know that one or more Committees of real estate men have been at work in this City in the last few years giving earnest study to proposed building legislation, but on the whole, it has been my experience, particularly in Albany, that help from the real estate interests is not easily secured. I would suggest that your Association have a permanent Committee on Fire Prevention — a Committee representative of every part of the State, which should include men of technical ability able to understand the schemes proposed and willing to give their time and their special knowledge to the problems that are presented. You would then be in a position to co-operate with other technical Committees — Committees of architects, builders, engineers and fire protection experts, who have long been working in various parts of the State, giving of their special knowledge to the service of the public without recompense, and in an honest, unprejudiced, unselfish spirit. It is only when every special trade, profession and industry in the whole community gives to the State of its special knowledge, as that knowledge may be needed, that we can have any approach to a real democracy.

The second means by which the real estate men can be of service is by working out for their own use practical solutions of the problems of fire prevention that are constantly coming up. The new laws and ordinances already in force involve many practical problems of construction, not only with regard to new buildings, but particularly with regard to existing structures. In the case of new buildings it is to be assumed that some architect, engineer or builder will work out a solution that is in conformity with the law, or better than what is required by law. I refer more particularly to the problems that occur in altering existing structures. Every property owner when served with notices requiring him to change certain portions of a building, to increase the exit facilities, to enclose existing staircases or elevators, to remove existing fire hazards, etc., apparently has to work out his own solutions of those problems, unless he consults some fire prevention expert. It seems to me that your Association could be of exceedingly great value if it were to undertake to prepare for the use of its own membership a series of simple construction sheets indicating various ways in which the dangerous parts of old buildings could be made to conform to the law. I can best illustrate by being specific: You might very well appoint a Committee (with proper technical advice) which would prepare a series of documents showing a half dozen different ways in which an open elevator shaft in a

building can be properly enclosed with fire resisting partitions and the necessary metal covered or metal doors. It might prepare a series of construction sheets showing how existing wooden staircases can be enclosed with fire resisting partitions, with the necessary self-closing doors. It might indicate by diagrams the various approved types of fire escapes for existing buildings, with the simplest and most practical means of construction, and diagrams showing the innumerable types of open air iron staircases, fire tower stairs, dumb waiter enclosures, horizontal exits, fire walls, etc. It seems to me that the preparation of a pamphlet or folder giving practical construction methods for all of these things would be a very important step in fire prevention work in this State, and would be greatly appreciated by your own members. They must constantly be appealed to by real estate owners for advice with regard to every one of these problems, and they ought to be able to present to such owners well studied but economical schemes for the solution of these problems.

Such steps on the part of the Real Estate Association would not only make your services of greater value to your clients, but show in no uncertain way to the public that the real estate interests of the State are heartily in favor of every practical means of preventing the colossal existing risk of loss of both life and property by fire.

# Pittsburgh Fire Prevention Meeting.

## Dinner of Credit Men's Association, December 7th.

From Journal of Commerce, N.Y.

The fire prevention dinner of the Pittsburgh Association of Credit Men, given Tuesday night at the Fort Pitt Hotel, attracted special attention, because of the recent report of the Pittsburgh city council committee on the Union Paper Box Co. holocaust which censured the Director of Public Safety and his subordinates for neglect of duty and recommended the dismissal of the superintendent and assistant superintendent of the Bureau of Building Inspection and the inspector of the Board of Fire Prevention. The mayor and the officials who are under fire were present at the dinner on invitation of D. C. Shaw, chairman of the Credit Men's Fire Prevention Committee, which had charge of the meeting. The speaker of the evening was Secretary Wentworth, of the National Fire Protection Association. Mr. Wentworth did not refer directly to the local matter which was so obviously in the minds of the gentlemen present but in closing his speech left no doubt as to his personal opinion that the Pittsburgh council committee had not got to the bottom of the problem in its condemnation of

the city officials. He said: "When I lived in Chicago a dozen years ago it was the fashion of the so-called reform forces to periodically descend upon the red light district and drive its residents into some other quarters of the city with much hue and cry and general condemnation of the city officials. In the course of a year another set of reformers would successfully drive them back, with equal publicity for their efforts. General rejoicing would follow that the city officials had been shown up and the city purified.

"At the enthusiastic peak of one of these movements a modest citizen came forward with a list of owners of the properties in which the undesirable traffic was carried on; the men who were taking the wages of the inmates in the form of rent. He suggested that if the reformers really wished to stop the traffic they need not drive the poor unfortunates back and forth while responsible people who were the real beneficiaries of the business might so easily be located.

"There is never a factory fire attended by loss of life that the head of some public official is not sought by somebody in expiation. Far be it from me to underrate the heavy responsibility of those to whom the people entrust the public safety. Amid the frightful hazards of modern civilization they should neither slumber nor sleep. They are almost the only protection a profit-seeking society offers the poor working girl, and their failure to guard her from conditions which may cause her death is a grave offence indeed. But there is another culprit whose responsibility is more fundamental, and he is the manufacturer or the landlord whose revenues are the silently capitalized evasions of his public and private duty.

"There is no monstrous mystery in fire prevention. Every place where human beings are employed can be made reasonably if not absolutely safe from fire, and the means of doing this may now in every case be known forthe asking. The man who waits for a city official to persuade or coerce him into making his premises fire safe is unfit for the administration of property. The initiative should rest with him. He should himself seek out the City Hall for advice in what is properly his affair. No other person's responsibility can by any possibility equal his own.

"The property owner's obligation is fundamental. This obligation cannot be hid by defective building codes, indulgent inspection departments, or other scapegoats for individual neglect. The man who accepts profit or rents from a business housing working men and women in conditions which may cost them their lives, is gambling in human life, and if the games goes against him he should pay to the uttermost farthing of his estate. The common whine made over the bodies of innocent victims that 'he didn't know the danger of his plant' should in the eyes of all honest men constitute his supreme indictment. It is his business to know, before he opens his door to unsuspecting human occupancy."

# Fire Waste of Year 1915.

**Fire Loss Figures Show Reduction of $52,755,100 Compared with 1914 Record — Distribution of the Waste in 1915 Was Fairly Even as Regards Entire Country.**

The losses by fire in the United States and Canada during the calendar year 1915, as compiled from the records of the Journal of Commerce, aggregated $182,836,200, showing the very handsome reduction of $52,755,100 from the figures of the previous year, which were $235,591,350. The fire loss record for 1915 is the smallest the country has enjoyed since 1905, when the figures recorded were $175,193,800. The 1915 losses present the first hopeful sign that all the efforts being put forth to reduce the appalling fire waste of the nation are beginning to bear fruit. It also reflects an improvement in the moral hazard under the influence of better general business conditions throughout the country.

## Distribution of Fire Waste.

The Journal of Commerce further says:

The distribution of the fire waste for 1915 was fairly even as regards the entire country, no section being noticeably affected with an undue share. A feature of the record, however, is that during the early months of the year there were several extra heavy lumber losses. There were also a number of quite heavy grain elevator losses, and during the late fall months cotton losses became quite prominent. Fires in plants engaged in war munition contracts were very numerous, in some instances reaching large proportions. These fires were in some instances attributed to incendiarism, but the general belief prevailed that the high pressure at which such plants were working prevented the usual care of proper safe-guards, thus contributing to outbreaks which, as the actual causes were undeterminable, were attributed to incendiarism.

## Educational Work Is Seen.

During the year just closed there has been a marked increase in the popular realization of the importance of reducing the annual fire waste of the country as an economic proposition worthy of consideration. This has been reflected in legislation of character to restrict carelessness, and in some states it has gone so far that bills have been introduced in the respective legislatures which, if enacted into laws, would put a direct liability on property owners in whose premises fires originated for the damage to the property of others due to the spread of such fires. Political organizations in all sections of the country have become more cognizant of the fact that they can best reduce the cost of protection against fire loss by reducing the burning ratio, and this is reflected in their change in attitude toward fire prevention legislation.

## Needs Still Further Reduction.

Despite the fact that the 1915 fire waste was a creditable one when compared with recent years, the total is too large when it is considered that it represents one year's financial drain on the resources of the country. The aggregate fire waste of

the United States and Canada during the past thirty-nine years, from 1877 to 1915, inclusive, reaches the vast total of $6,049,817,225, equal to an average annual loss of $155,123,518. The following table, giving the fire losses by years during the past thirty-nine years, reveals that 1915 is the first break in the steadily enlarging tendency of the country's fire waste, which break is hoped to be permanent:

## Losses During 39 Years.

| | | | |
|---|---|---|---|
| 1915 | $182,836,200 | 1895 | $129,835,700 |
| 1914 | 235,591,350 | 1894 | 128,246,400 |
| 1913 | 224,728,350 | 1893 | 156,445,875 |
| 1912 | 225,320,900 | 1892 | 151,516,000 |
| 1911 | 234,337,250 | 1891 | 143,764,000 |
| 1910 | 234,470,650 | 1890 | 108,893,700 |
| 1909 | 203,649,200 | 1889 | 123,046,800 |
| 1908 | 238,562,250 | 1888 | 110,885,600 |
| 1907 | 215,671,250 | 1887 | 120,283,000 |
| 1906 | 459,710,000 | 1886 | 104,924,700 |
| 1905 | 175,193,800 | 1885 | 102,818,700 |
| 1904 | 252,554,050 | 1884 | 110,008,600 |
| 1903 | 156,195,700 | 1883 | 110,149,000 |
| 1902 | 149,260,850 | 1882 | 84,505,000 |
| 1901 | 164,347,450 | 1881 | 81,280,000 |
| 1900 | 163,362,250 | 1880 | 74,643,400 |
| 1899 | 136,773,200 | 1879 | 77,703,700 |
| 1898 | 119,650,500 | 1878 | 34,315,900 |
| 1897 | 110,319,650 | 1877 | 68,265,800 |
| 1896 | 115,655,500 | Total | $6,049,817,225 |

## Losses by Months.

The losses by fire during 1915 when considered by months reflect the very material decrease that occurred during the summer months as compared with the monthly record of previous years. This may be accounted for in a great measure by the fact that the summer season of 1915 was free from any serious drouths and resultant forest fires. The following table affords a comparison of the losses by months during 1913, 1914 and 1915:

| | 1913. | 1914. | 1915. |
|---|---|---|---|
| January | $20,193,250 | $23,204,700 | $20,060,600 |
| February | 22,084,600 | 21,744,200 | 13,081,250 |
| March | 17,511,000 | 25,512,750 | 18,786,400 |
| April | 16,738,250 | 17,700,800 | 18,180,350 |
| May | 17,225,850 | 15,507,800 | 11,388,450 |
| June | 24,942,700 | 29,348,000 | 10,893,950 |
| July | 20,660,900 | 17,539,800 | 9,006,800 |
| August | 21,180,700 | 11,765,650 | 10,067,100 |
| September | 17,919,300 | 14,383,050 | 14,823,500 |
| October | 14,932,750 | 14,004,700 | 14,465,850 |
| November | 15,207,600 | 21,372,750 | 21,204,850 |
| December | 16,126,450 | 23,507,150 | 20,877,100 |
| Total | $224,723,350 | $235,591,350 | $182,836,200 |

# A New Panel Testing Furnace.

## NOTES ON THE DESIGN AND OPERATION OF A LARGE FURNACE RECENTLY COMPLETED AT THE UNDERWRITERS' LABORATORIES.

By J. E. Latta (Member N. F. P. A.).

As most readers of the QUARTERLY are doubtless aware, fire tests on structural materials have long been a very important division of the work of the Underwriters' Laboratories. Among the more interesting products and appliances subjected to the fire test are various sorts of proprietary building materials, materials used for fireproof partitions, materials in the form of brick, wired glass, wired glass windows, metal fire doors, metal-clad fire doors, and so on.

The tests on such products undertake primarily to determine their fire-retardant qualities; but for purposes of comparison, it is usually necessary also to obtain reliable information relative to structural values.

Briefly stated, the method employed consists of subjecting the device or material to a fire of sufficient intensity and duration to indicate clearly the ultimate fire-resisting point, the test conditions being selected to approximate as nearly as practicable the more extreme exposures to which the device or material is liable to be subjected under actual service conditions. Unless the sample has been so weakened or damaged by the exposure to fire that this would serve no good purposes, a stream of water is usually applied to the sample at the conclusion of the test. It is intended thus to ascertain the effect of rapid cooling and also the behavior of the product under the impact of a fire stream while at a high temperature.

The tests are made in gas furnaces designed and built to meet the special requirements of each particular class of work. Auxiliary equipment includes a traveling crane for handling the panels in which the test samples are mounted, apparatus for measuring the temperature on both sides of the exposed sample and the transmission of heat through it, nozzles for providing the fire steam, a special type of stand for service in the installation of the test sample, machines for strength tests, and apparatus for testing heat insulating materials.

Since Underwriters' Laboratories began tests of the sort under consideration, there have been built at the Chicago plant a number of gas furnaces for this work. The following notes undertake a brief description

of a furnace just completed. This is the largest unit of its kind that has been provided up to the present time; in its design and construction there are embodied many special features that are believed to be new and distinctive.

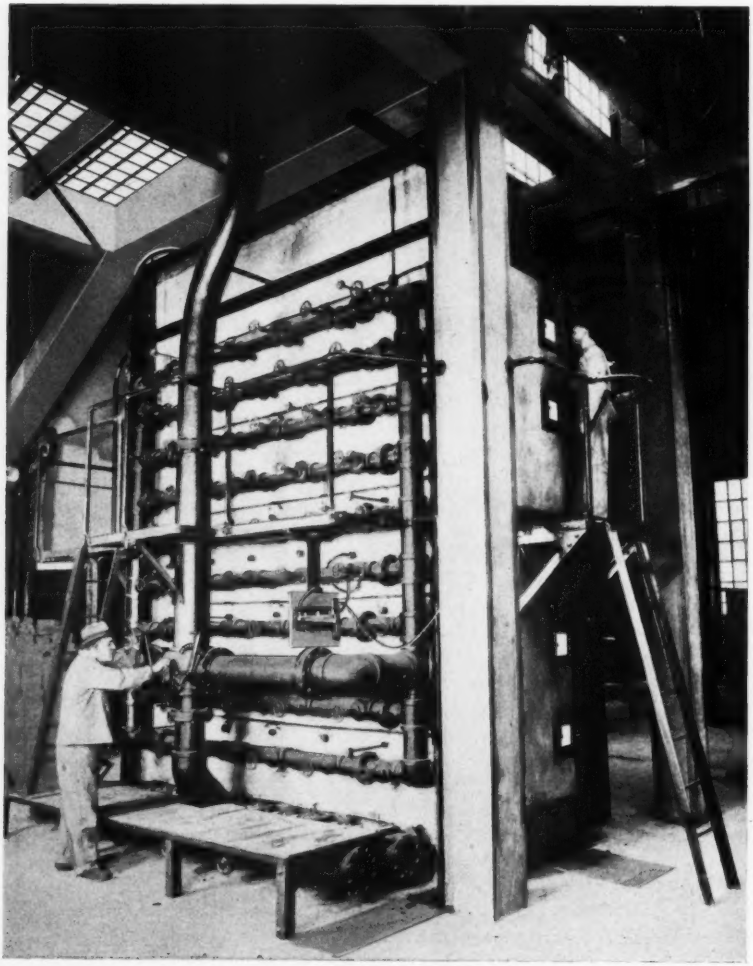


Fig. 1

**Panel Testing Furnace. View of rear and end of furnace showing piping, control valves, observation gallery, pressure gauges and furnace thermo-couples.**

## Panel Testing Furnace.

The furnace proper consists of a shallow combustion chamber approximately 16 inches deep, 12 feet wide and 14 feet and 9 inches high. Communicating with it at the bottom is a pit 19 inches wide and 36 inches deep. The combustion chamber, wherein the fire is maintained against

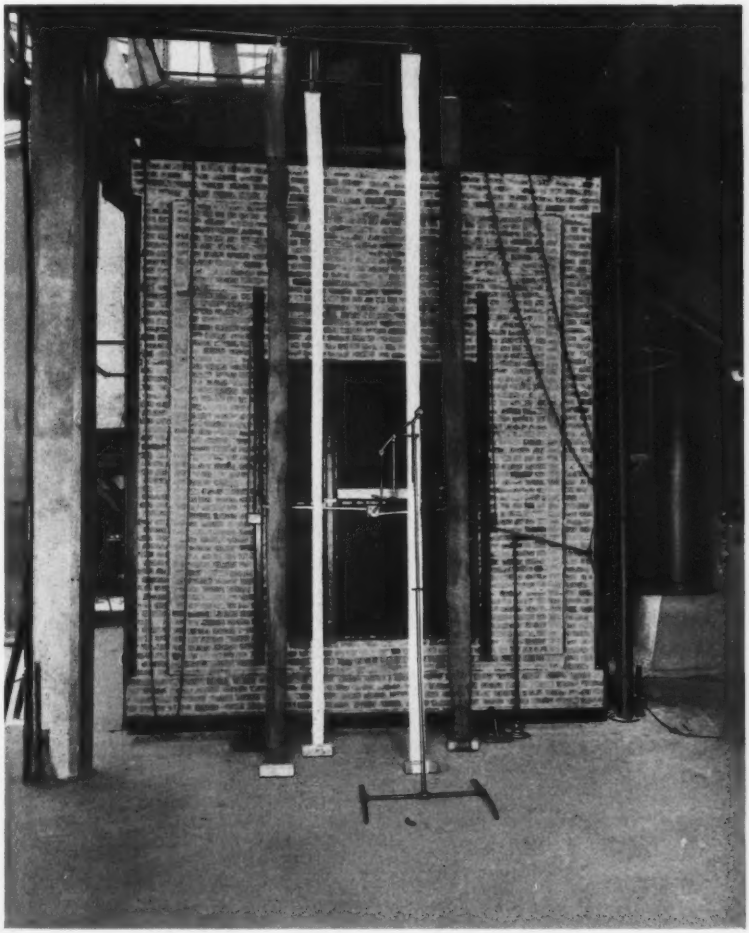


Fig. 2

**Panel Testing Furnace. Counterbalanced elevator door installed in panel preparatory to test, with typical arrangement of cloth strips, thermo-couples and thermometers for indicating amount of heat transmitted and radiated during test.**

Fig. 3

Panel Testing Furnace. Illustrating method of applying fire stream to the heated side of a test sample immediately after a fire test.

one side of the sample under test, is enclosed at the back and one end by substantial stationary brick walls; movable walls in steel frames make up the front and other end of the enclosure. The front movable wall is suspended from an overhead steel beam by trolleys and the movable end wall is carried by flanged wheels which run upon rails within the floor.

In a panel testing furnace like the one here under consideration, products to be tested may be such that the necessary test sample will form the entire front wall of the furnace, filling completely the steel frame for this wall and subjecting the frame and the supporting trolley to great weight; or the appliance under test may be light and may require but a comparatively small space in the combustion chamber, as is the case with wired-glass windows, the smaller fire shutters, etc. See Fig. 2 for illustration. Four panel frames are supplied with the new furnace at the Laboratories. The largest and strongest one will accomodate test samples weighing as much as 24,000 pounds. The frame itself for this particular panel weighs about 14,000 pounds.

The top of the furnace consists of heavy fire-clay blocks, and has six vents which lead to a stack. Dampers made of suitable fire-resisting materials are installed in the vents referred to.

That one of the end walls which is movable is at the end where the test sample is moved into and out of the furnace. This wall is shown in Fig. 1 with an attendant peering in at the topmost window through it. Portability of this part of the unit makes satisfactory sealing of the furnace easier and is necessary for the withdrawal of the front wall when it contains a test sample which projects into the combustion chamber.

Each end wall of the furnace has three observation windows glazed with mica and so arranged that all parts of the combustion chamber and the exposed side of the test sample may be readily observed. An observation gallery affords access to the upper windows and the valves at the top of the rear of the furnace.

The heat supply is provided by means of six 4-inch blast burners installed in the base of the back wall of the combustion chamber, the arrangement being such that the discharge is upward at a small angle, and each of these six burners carries a screen of special design to prevent flashing back. Fuel, consisting of a mixture of gas and air, is conveyed to the burners through mixing-tubes of suitable design.

A secondary air supply consists of 50 air inlets spaced uniformly over the back wall of the furnace, in the nine horizontal rows shown in Fig. 1.

The flow of gas to the burners is regulated by means of individual valves, one for each burner, and these have graduated scales, so that the valve setting may be duplicated accurately.

In the air supply line there are three butterfly valves, one controlling the entire primary air supply and each one of the others controlling one-half of the secondary supply. Individual air valves, equipped with dial pointers to permit duplication of adjustment, are provided for the six gas burners. It is thus seen that the proportion of air to gas can be adjusted in all the burners simultaneously and that this adjustment can also be

made for any given burner without interfering with any of the others. The flow of air to each of the fifty secondary air inlets is likewise controlled by an individual valve.

Gas is supplied to the furnace through a 6-inch pipe connected directly to the street main. The air supply is from a blower system capable of furnishing something over two thousand cubic feet per minute at a pressure responding to a head of 13.8 inches of water.

### Temperature and Pressure Measurements.

Thermo-couples are employed for measuring the high temperatures within the gas furnace and on the exposed side of the material under test, the number and positions of these depending largely upon the size and nature of the test sample. The thermo-couples are enclosed separately in steel pipes, for which there are openings through the back wall of the furnace, and each pipe has an iron case at the cold end which contains the cold junctions and is equipped with a mercury thermometer protected by a metal jacket. The couples are wired to a switchboard of suitable type conveniently located.

On the unexposed side of the test sample temperatures are taken by means of thermo-couples, and by mercury thermometers hung in various positions.

Fire pressures within the furnace are indicated by means of a draft gauge connected to the combustion chamber by piping. The equipment also includes provision for the measurement and control of the pressure in the air supply.

### Fire Stream Apparatus.

In Fig. 3, material that has been exposed to the fire is being subjected to the impact of the fire stream immediately following its withdrawal from the furnace. The apparatus employed in the fire stream test consists of special hydrants located at convenient points, flexible nozzles attached to the hydrants, gate valves for controlling the streams, and pressure gauges at the bases of the nozzles. The tip of the nozzle is held 20 feet from the sample when the wall is pulled from the test furnace. The hydrants are connected to the water mains under the floor. The source of water supply to these may either be three 4,500-gallon pressure tanks or an electrically driven fire pump having a capacity of 500 gallons per minute. The tanks and pump are located in an adjacent building.

# Fire Tests of Building Columns

## At Underwriters' Laboratories, Chicago.

## PROSPECTUS.

**Note: Members having criticisms or suggestions to offer on the details of these plans are urged to communicate at once with the Laboratories.**

## INTRODUCTION.

The Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters and the National Bureau of Standards propose to carry out a series of tests to determine the ultimate fire resistance of representative, loaded building columns, and the fire-resistive value of various forms of column protection.

The facts that very few tests have been made under conditions approximating those of service, that available test data are incomplete, that fire experience has a limited value due to many variable and unknown factors and the existence of wide differences in requirements covering various materials used for the protection of columns, all show the necessity for the proposed investigation.

The columns designed to carry the lighter loads have been selected for this preliminary series of tests in the belief that the results obtained will not only furnish the necessary information relative to the lighter column sections, but will afford data that will permit the elimination of a number of variables, and simplify the investigation of columns designed for the greater loads.

Tests in which fire streams are applied to the heated columns are not to be included in the first series of tests inasmuch as it is believed that the ultimate fire-resisting points should first be ascertained and considered in connection with the influence of the column sections and methods of fire-proofing before tests are made to determine the effect of the application of water.

The columns that are protected by concrete, clay tile or gypsum block are to be tested in the unplastered condition, since in some types of buildings plaster is not applied, and it is believed that any investigation of the influence of the different kinds of plaster on fire resistance can best be made with the fire resistance of the unplastered member as a basis.

### General Plan of Investigation.

The object of this investigation is to ascertain the ultimate fire resistance of centrally loaded columns used in the interior of buildings, under conditions approximating those of service; to ascertain the fire

retardant value of the column protection provided by the various materials and methods commonly employed in protecting columns against fire; to obtain full and accurate data that will serve as a basis for the classification of column protection for various classes of buildings; and to furnish data for guidance in the determination of proper test conditions for heavier columns, and special tests to ascertain the effect of the application of fire streams to columns while in a highly heated condition.

Test columns consisting of the types of columns commonly employed in building construction, specially designed for the test apparatus and for safe rated loads of approximately fifty (50) tons, have been secured.

It is proposed to protect these columns, except one of each type, by various methods commonly employed in fireproofing building columns, and to allow them to season under proper conditions for a period of six months before they are tested. See Description of Test Samples.

It is proposed to make supplementary standard tests to ascertain the quality of the materials employed in the construction of the test columns.

It is proposed to subject each of the columns to its safe rated load and to temperatures increasing at a predetermined rate until failure, or until the column has withstood the temperature conditions in excess of eight hours.

It is proposed to measure and record at regular intervals during the test, the temperatures in the furnace and at various points on the surface of the structural portion of the column, the deformation and deflection of the column near the middle, and to record the results of observations relative to the effects of fire on the column and on the column protection.

It is proposed to make careful examinations after the test and a record of the condition of the column and column protection.

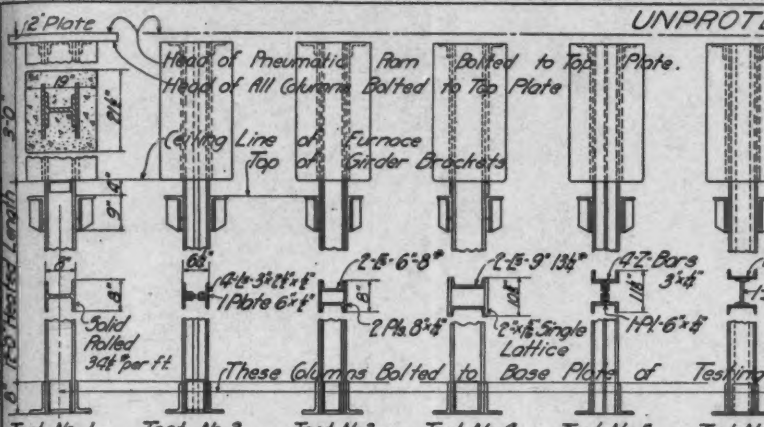
It is proposed to make photographic records of the column before and after the test, and after the column protection has been removed.

It is proposed to make a supplementary series of tests upon additional test columns to determine the effect of the application of fire streams to columns while in a highly heated condition.

## Description of Proposed Test Columns.

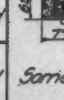
The types of columns to be tested include rolled steel sections, built up steel sections, round cast iron sections, steel pipe filled with concrete, and vertically reinforced and hooped concrete columns, to which it is proposed to add several wooden columns. At least one of each of the sections is to be unprotected, others are to be partially protected by concrete, and others completely protected by various thicknesses of concrete, clay tile, gypsum blocks and plaster on metal lath, in accordance with the methods commonly employed in practice. The general details of the test columns and methods of covering are indicated in the attached schedule, which also shows the position of the ceiling and floor lines of the furnace and the method of grouping the columns for comparison.

# SCHED
## JOINTLY CONDUCTED FIRE
### UNPROT

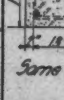

12" Plate
Head of Pneumatic Ram Bolted to Top Plate.
Head of All Columns Bolted to Top Plate
Ceiling Line of Furnace
Top of Girder Brackets
9'-4"
68"
4-4"x3½"x⅜" & 1 Plate 6"x⅜"
2-15"-6"-8"
2-15"-9"-13¼"
4-Z-Bars 3½"x⅜"
1-Pl 6"x⅜"
2 Pls. 8"x⅜"
2-3"x⅜" Single Lattice
Solid Rolled 34# per ft.
These Columns Bolted to Base Plate of Testing
Test No. 1, "H" Section
Test No. 2 Plate & Angle
Test No. 3 Plate & Channel
Test No. 4 Lattic'd Channel
Test No. 5 Z-Bar & Plate
Test No I Bm. & Ch

NOTE: The structural steel and cast iron sections of the p
unprotected section, the total and heated lengths of all partly protected
the general details and top and bottom anchorage are the same as for the

## PARTLY PROTECTED COLUMNS

| TEST NO. SECTION | TYPICAL SECTION | DETAILS |
|---|---|---|
| 14 Rolled "H" | | Concrete: 1-Portland Cement 2-Joliet Sand 4-Joliet Gravel |
| 15 Rolled "H" | Same as No. 14 | Concrete: 1 Portland Cement 2-Plum Island Sand 4-New England Granite |
| 16 Plate and Angle |  | Concrete: 1-Portland Cement 2-Long Island Sand 4-New York Trap Rock |
| 17 Plate and Angle | Same as No. 16 | Concrete: 1-Portland Cement 3-Long Island Sand 5-Hard Coal Cinders |
| 18 Latticed Channel | | Same as No. 16. |
| 19 Z Bar and Plate | | Concrete: 1-Portland Cement 3-Fox River Sand 5-Chicago Limestone |
| 20 I Beam and Channel | | Concrete: 1-Portland Cement 3-Long Island Sand 5-New York Trap Rock |
| 21 I Beam and Channel | Same as No. 20 | Concrete: 1-Portland Cement 2 Cleveland Sand 4-Cleveland Sandstone |
| 22 Latticed Angle | | Concrete: 1-Portland Cement 2-Fox River Sand 4-Chicago Limestone |

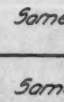
## COLUMNS PROTECTED BY PLASTER ON METAL LATH

| | | |
|---|---|---|
| 23 Plate and Angle | | Plaster-1:3:2½ Portland Cement Hyd. Lime and Lake Sand. Inner layer to consist of two brown coats, outer layer to consist of two brown coats and one finish coat in which lime is omitted. Hair to be added to first coat. Each layer to be approx. one inch thick. Metal Lath - No. 24 Diamond Mesh. Painted. 3½ per sq yd. min. wt. |
| 24 Plate and Channel |  | |
| 25 Z Bar and Plate | | |
| 26 Latticed Angle | | Same as Nos. 23 to 25 except plaster is to be in one layer 2" thick consisting of two brown coats and one finish coat. |
| 27 Cast Iron | | Plaster - Same as No. 26 except no hair is used. Metal Lath - Integral No. 26 Painted. 3½ per sq yd. min. wt. |

## REINFORCED CONCRETE COLUMNS

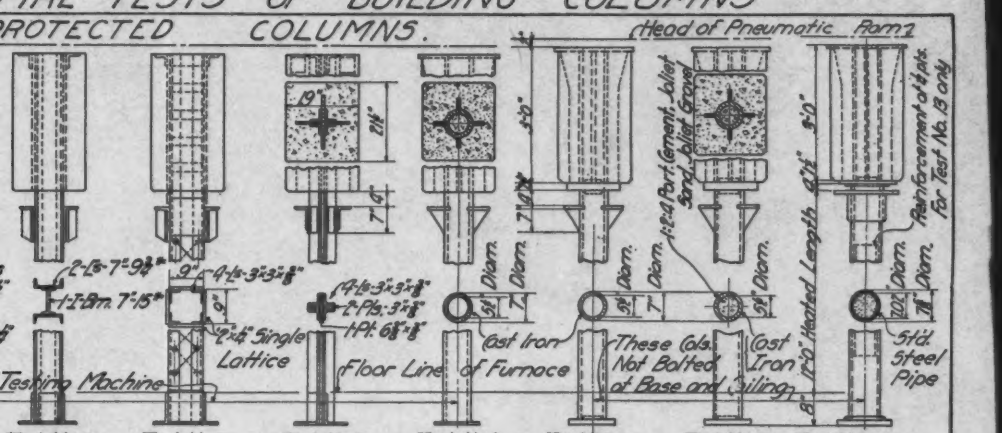
| | | |
|---|---|---|
| 68 13"x13" 4-1" Sq. | | Concrete: 1-Portland Cement 2-Fox River Sand 4-Chicago Limestone |
| 69 13"x13" 4-1" Sq. | Same as No. 68 | Concrete: 1-Portland Cement 2-Long Island Sand 4-New York Trap Rock |
| 70 14½" Diam. 4-1" Sq. | | Same as No. 68 |
| 71 14½" Diam 4-1" Sq. | Same as No. 70 | Same as No. 69 |
| 72 12½" Spiral Hooped Core 4-⅞" Sq. |  | Same as No. 68 |
| 73 12½" Spiral Hooped Core 4-⅞" Sq. | Same as No. 72 | Same as No. 69 |

## COLUMNS PROTECTED

| TEST NO. SECTION | THICKNESS | TYPICAL SECTION |
|---|---|---|
| 28 Rolled "H" | 2" | |
| 29 Rolled "H" | 2" | Same |
| 30 Rolled "H" | 2" | Same as |
| 31 Rolled "H" | 2 | Same as |
| 32 Rolled "H" | 2" | Same as |
| 33 Rolled "H" | 4" |  |
| 34 Rolled "H" | 4" | Same as |
| 35 Rolled "H" | 4" | Same |
| 36 Plate and Angle | 2" | |
| 37 Plate and Angle | 4" | |
| 38 Plate and Channel | 2" | |
| 39 Plate and Channel | 4" | |
| 40 Latticed Channel | 2" Outside of Lattice | |
| 41 Z-Bar and Plate | 2 | |
| 42 Z-Bar and Plate | 4" | |
| 43 I Beam and Channel | 2" | |
| 44 I Beam and Channel | 4" | |
| 45 Star Section | 3" | |
| 46 Latticed Angle | 2⅝" Outside of Lattice | |
| 47 Cast Iron | 2" | |

# HEDULE OF FIRE TESTS OF BUILDING COLUMNS

## PROTECTED COLUMNS.




The partly and fully protected columns are the same as the corresponding ected, fully protected and reinforced concrete columns are 15'-8" and 12'-0" respectively, for the unprotected structural steel and restrained cast iron columns.

| PROTECTED BY CONCRETE | | COLUMNS PROTECTED BY TILE | | | | |
|---|---|---|---|---|---|---|
| TYPICAL SECTION | CONCRETE MIXTURE | TEST NO. SECTION | THICKNESS | TYPICAL SECTION | GRADE OF CLAY OR GYPSUM | FILLING |
| No. 5 B. & S. Ga. Wire 8" Pitch | 1-Portland Cement 2-Fox River Sand 4-Chicago Limestone | 48 Rolled "H" | 2" Tile, ¾" Mortar | | Low Grade Fire Clay Perth Amboy District | 1:3:5-Portland Cement, Long Island Sand N.Y. Trap Rock |
| Same as No. 28 | 1-Portland Cement 2-Long Island Sand 4-New York Trap Rock | 49 Rolled "H" | 4" Tile ¾" Mortar | | Same as No. 48 | Same as No. 48 |
| Same as No. 28 | 1-Portland Cement 2-Joliet Sand 4-Joliet Gravel | 50 Plate and Angle | 2" Tile ⅜" Mortar | | Surface Clay New England District | 1:3:5-Portland Cement, Plum Island Sand, New Eng. Granite |
| Same as No. 28 | 1-Portland Cement 2-Cleveland Sand 4-Cleveland Sandstone | 51 Plate and Angle | 4" Tile 1" Mortar | | Same as No. 50 | Same as No. 50 |
| Same as No. 28 | 1-Portland Cement 2-Long Island Sand 4-Hard Coal Cinders | 52 Plate and Channel | 2" Tile ⅜" Mortar | | Shale Cleveland, Ohio. District | 1:3:5-Portland Cement, Cleveland Sand, Cleveland Sandstone |
| No. 5 B. & S. Ga. Wire Spiral 8" Pitch | Same as No. 28 | 53 Plate and Channel | 4" Tile ⅜" Mortar | | Same as No. 52 | Same as No. 52 |
| Same as No. 33 | 1-Portland Cement 2-Plum Island Sand 4-New England Granite | 54 Latticed Channel | 2" Tile ⅝" Mortar | | Surface Clay (1) Chicago District | 1:3:5-Portland Cement, Fox R. Sand, Chicago Limestone |
| Same as No. 33 | 1-Portland Cement 3-Fox River Sand 5-Chicago Limestone | 55 I-Bar and Plate | 2" Tile ⅜" Mortar | | Same as No. 54 | Same as No. 54 |
| No. 5 B. & S. Ga. Bright Basic Wire in tight spirals 6" pitch, for Tests Nos. 28 to 45 | Same as No. 29 | 56 I-Bar and Plate | 4" Tile 1" Mortar | | Same as No. 54 | Same as No. 54 |
| | 1-Portland Cement 6-Broken Tile Dust and Broken Tile | 57 I-Beam and Channel | 4" Tile ⅝" Mortar | | Surface Clay (2) Chicago District | Same as No. 54 |
| | Same as No. 30. | 58 I-Beam and Channel | 4" Tile ⅜" Mortar | | Same as No. 57 | Hollow Clay Tile 2"x12"x6" at End 3"x12"x6" at Side |
| | 1-Portland Cement 2-Meramac R. Sand 4-Meramac R. Gravel | 59 I-Beam and Channel | 2-2" Tile ⅜" Mortar | | Same as No. 57 | Same as No. 54 |
| | Same as No. 29 | 60 Latticed Angle | 2" Tile ⅝" Concrete | | Same as No. 54 Filling placed before Tile is set | 1:2:4 Port. Cem. Fox R. Sand Chicago Limest. |
| | Same as No. 28 | 61 Latticed Angle | 2" Tile ⅝" Mortar | | Same as No. 54 | No Filling |
| | Same as No. 28 | 62 Cast Iron | 2" Tile ⅜" Mortar | 2-1'8" Diam. Inside Lugs x 12" lg. | Same as No. 48 Lug Tile | No Filling |
| | Same as No. 31 | 63 Cast Iron | 2" Tile ⅜" Mortar | 2-8" Diam. Inside x 12" lg. | Same as No. 48 Hollow Tile | No. Filling |
| | Same as No. 31 | 64 Rolled "H" | 4" Gypsum Tile ⅜" Mortar | Solid | Gypsum from Central Western States | Hollow Gypsum Tile 4"x12"x30" Cut |
| | Same as No. 29 | 65 Plate and Channel | 2" Gypsum Tile ⅜" Mortar | Solid | Same as No. 64 | Solid Gypsum Tile 2"x5"x12" Interior not Filled |
| | Same as No. 28 | 66 Latticed Channel | 2" Gypsum Tile ⅝" Mortar | | Gypsum from Eastern United States or Canada | Solid Gypsum Tile 2"x5¼"x16½" Interior not Filled |
| No. 5 B. & S. Ga. Wire 8" Pitch ¾" Notched | Same as No. 32 | 67 I-Bar and Plate | 4" Gypsum Tile ⅜" Mortar | Solid | Same as No. 66 | Solid Gypsum Tile 2"x5¼"x16½" at End 2"x5"x16½" at Side |

The test columns, with the exceptions noted, are 15 feet 8 inches long between bearings. The upper 3 feet is made of extra heavy section to serve as a medium for the free transmission of the load from the ram through the roof of the furnace to the heated portion of the column. The extra heavy section is assumed to establish an effective length of 12 feet 8 inches as a basis for calculating the safe rated load of the column.

The pipe columns and two of the cast iron columns (Nos. 10 to 13 inclusive) are approximately 12 feet 6 inches in length and provided with square end bearings.

The test columns are provided with two brackets near the top to simulate the details used for beam and girder supports and conditions affecting the application of fireproofing at these points.

The materials used in the construction of the test columns and protective coverings are to be obtained from various sources and from various sections of the country, and are to be selected with a view of obtaining those representative of their respective classes.

It is proposed to apply the column covering in accordance with plans and specifications, drawn to secure average results obtained under ordinary commercial conditions, and to place this work in the hands of men sufficiently experienced in their particular line to obtain this result.

It is proposed to secure representative test samples of the materials for the supplementary tests to ascertain the quality of the materials used in the construction of the columns and column coverings.

The tests on unprotected columns are made to furnish information as to the ability of the columns to withstand fire, and to obtain information relative to the influence of the type of column section, which latter forms a basis for comparison of the various methods of column protection.

Columns partly protected by filling the re-entrant portions with concrete are introduced as a type made necessary where space limitations prevent the use of full protection. Besides giving information on the merits of this type of protection as compared with unprotected steel, cast iron and wooden columns, it is also thought that they will give further data on the influence of type of steel section on fire resistance. The concrete aggregates are the same as those used in the tests of the fully protected columns of the corresponding sections.

Of the twenty tests devoted to full concrete protection, the eight made on the Rolled H section employ, with three exceptions, all of the concrete aggregates used in the full series of tests. This is done to give a comparison between the Rolled H section and the other sections with the same thickness of covering made of the same aggregate. The coverings for the same section are in general proposed to be put on in two-inch and four-inch thicknesses, from which it is thought possible to judge the performance of intermediate thicknesses.

The tile coverings are similarly proposed to be put on in two-inch and four-inch commercial thicknesses, which consist of the designated thickness of tile plus one-half inch to one inch of mortar. The thickness of mortar between the tile and the steel sections is determined by the minimum

consistent with good placement, and the attainment of as nearly a constant average mortar thickness as possible using standard sizes of tile. The thickness outside of solid flanges varies in the proposed designs from ¾ to 1 inch, and outside of lattice bars and round sections from ½ to ⅝ inch. All-clay tile is to be called for in 12-inch widths, and the distance between the horizontal joints is to be 12 inches except at the beam brackets near the top. Slabs are to be placed in all vertical joints wider than ½ inch. All cutting of clay tile is to be done with a mason's trowel, except cutting to length, which is to be done with a stone saw in the cases where the lengths specified cannot be readily obtained. The mortar for clay tile coverings is proposed to be a 1:1:6 Portland cement, hydrated lime and fine bank sand by volume. It is proposed to place a No. 12 black annealed wire tie around each course of tile.

The clay tile is to be of a degree of hardness acceptable for interior building work, with an absorption of not less than ten per cent of its dry weight, as determined by drying to constant weight at 212° F. and immersing in water at room temperature and pressure for forty-eight hours.

The concrete filling is to be placed after the tile is set (except in No. 60) and is proposed to be made of the concrete materials peculiar to the region from which the tile is taken. Tests Nos. 57 and 58, as also Tests Nos. 60 and 61, are designed to study the effect of the filling on the efficiency of the covering as a whole.

The proposed gypsum protections consist of solid gypsum tile (except for filling in Test No. 64), the sizes needed being cut from the commercial sizes with a saw, the cutting being planned with a view to using them in the most economical manner consistent with a good design. The mortar as proposed will consist of a 1:2 mixture of unfibered gypsum cement and fine bank sand by volume. Ties are to consist of ½-inch wire mesh placed in all horizontal joints and lapping at the corners.

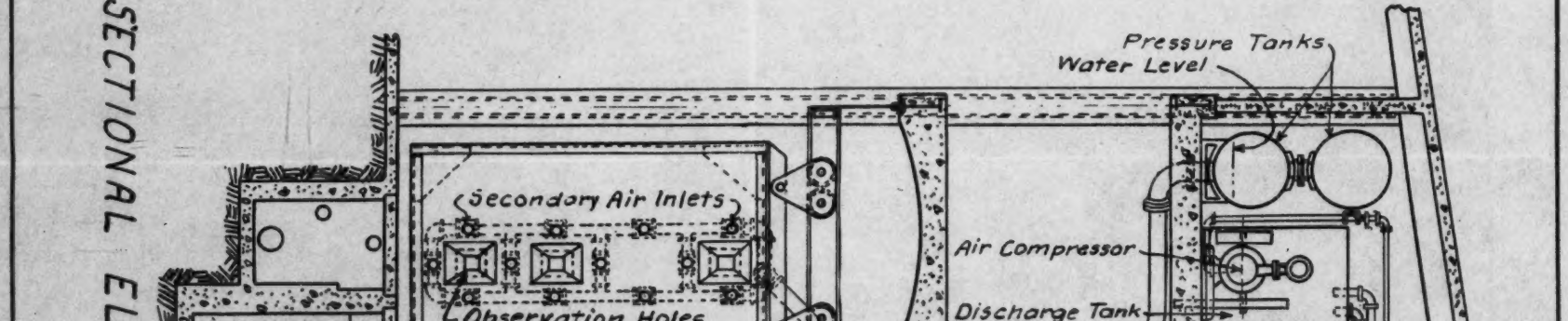
It is proposed to use a medium coarse lake sand, dredged from Lake Michigan, for the brown coats of the plaster on metal lath protections.

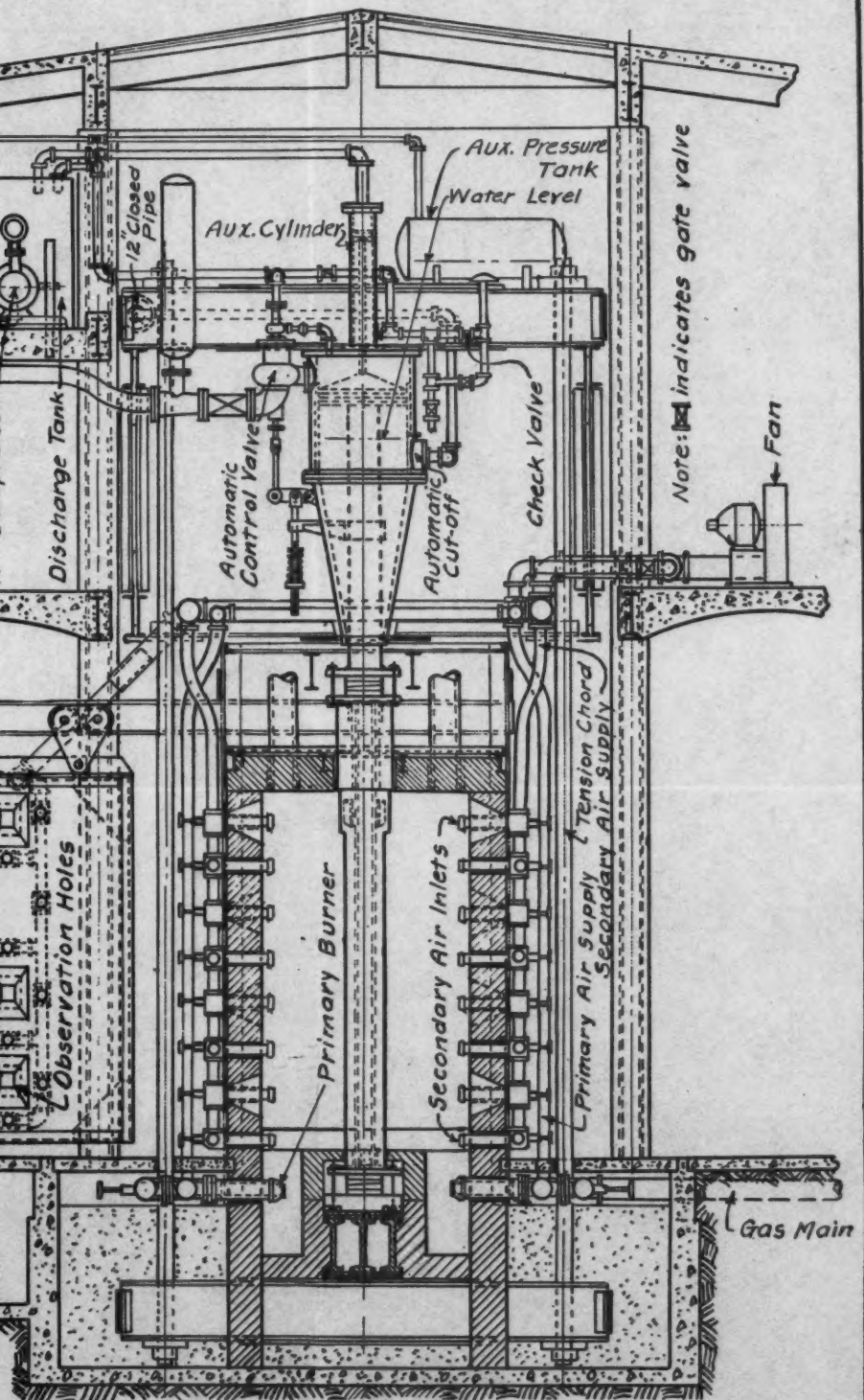
The projecting portions of the beam brackets at the top of the columns are to be given a protection of about 1-inch thickness for all fully protected columns.

The reinforced concrete tests, consisting of two vertical reinforced square columns, two vertically reinforced round columns, and two spirally hooped and vertically reinforced columns, are designed to show the effect of shape or column as also the effect of type of reinforcement on fire resistance. Two inches of concrete is to be deducted all around the column in calculating the safe rated load.

All Portland cement is to be of one brand, widely used for building construction. It is to be required to pass the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials. The coarse aggregates are to be graded from coarse to fine, not more than five per cent shall pass a No. 4 sieve, and all are to pass a sieve having 1-inch square mesh. All proportioning of concrete and mortar is to be done by loose volume.

SECTIONAL ELEVATION





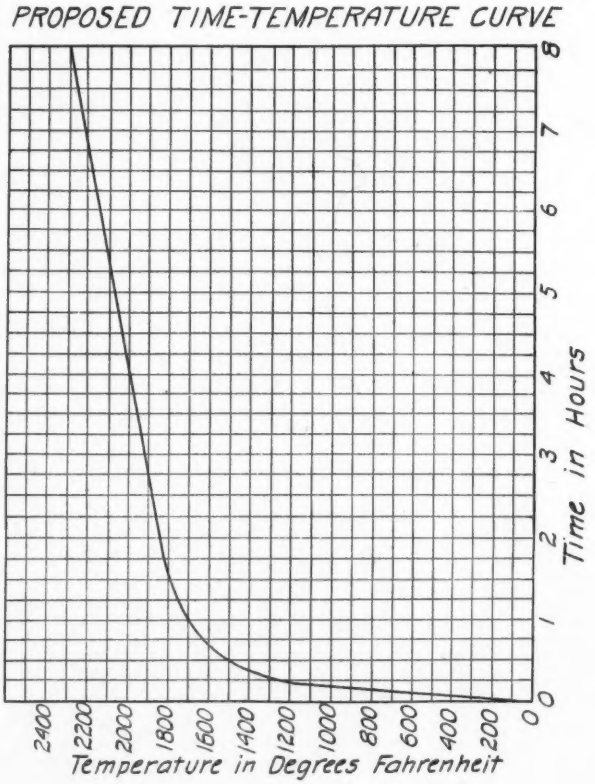

ELEVATION OF TESTING MACHINE

Scale: $\frac{3}{16}$" = 1'-0"

The furnace is heated by means of eight 6-inch specially designed blast burners, extending in at the corners and the middle of the sides, and arranged so that they discharge horizontally toward the center of the combustion chamber at the bottom. The burners are supplied with gas through mixing tubes connected to circulating mains located in a shallow pit under the floor outside of the furnace. Each burner is provided with valves for regulating the gas and air.

The additional air necessary to complete combustion and distribute the fire is supplied by secondary air inlets extending through each side of the furnace at regular intervals toward the top, each inlet being provided with a regulating valve.

Gas is supplied to the furnace through a six-inch pipe connected to the street main. Air is supplied to the burners and to the secondary inlets by means of an electrically driven blower capable of maintaining uniform air pressure.



*Temperature Measurements.*

The temperatures within the furnace are indicated by means of thermo-couples inserted through the walls near the top, middle and bottom. The temperatures at the surface of the structural portion of the test column are indicated by thermo-couples placed at the same levels as the furnace couples.

*Deformation Measurements.*

The deformation and deflection of the column during test is to be taken by measuring the movements of protected wires attached near the middle of the column. One end of each wire is attached to the column and the other is weighted and passed over an idler at a point outside of the furnace and as far from the column as the room conditions permit. The movement is measured at an intermediate point on the wires, and the true movement at the point of attachment to the column calculated from the established ratio of distances.

*Loading Apparatus.*

The apparatus to be employed in applying the loads to the columns during the fire and fire and water tests consists essentially of a hydro-pneumatic ram, the pumps and tanks supplying the pressure, restraining frames, and pressure indicating, controlling and recording apparatus.

The ram has a rated capacity of approximately 256 tons and is bolted to the under side of the heavy steel beams forming the top of the restraining frame in such a manner that it will engage the top plate of the test column when in position. The column transfers the compression to the beams, constituting the bottom of the frame, which complete the action by transferring the stresses back to the top through steel tension chords forming the sides of the frame. The framing supporting the restraining frame at the top is also designed to aid in supporting laterally the lower end of the ram, and resist any racking set up by eccentricity of the loads when the test columns are deformed in the tests.

The ram is designed to automatically maintain the load on the test column and develop characteristic deformation at the point of failure. In case of sudden complete failure, the loss of the load is judged to be immaterial inasmuch as the load at which the column fails is known. In case of gradual failure, such as can be expected in the majority of cases, the ram is capable of maintaining the load until characteristic deformation of the column is secured. In case of sudden but incomplete failure of the test column, some loss in the load may take place, but this will be automatically recorded and is not considered important inasmuch as the full load throughout the complete period of deformation would probably only increase the rate of deformation, the characteristics of which have already been observed.

The ram is connected by a 6-inch pipe to steel tanks in which the operating water and air pressures are stored, and is provided with a con-

trolling valve that can be set to automatically shut off the pressure after any predetermined downward movement of the plunger less than 24 inches has taken place. It is also designed to absorb the impacts and withstand the pressures in case of the failure of the automatic controlling valve. A separate lifting cylinder and pressure tank by means of which the plunger of the ram can be independently raised and lowered is attached to the ram. Water and air pressures as high as 500 pounds to the square inch are supplied by an electrically-driven pump and compressor. The pumps and tanks are equipped with the necessary pressure gauges and the ram with pressure recording apparatus. The connections are provided with the valves necessary for the manual control of the loading apparatus.

Adjustable bearings are provided at the top and bottom of the test columns to insure the central application of the loads.

### *Apparatus for Testing Materials.*

Standard apparatus is to be employed in the supplementary tests to ascertain the quality of the materials used in the construction of the columns and column protection.

### *Fire Stream Apparatus.*

The apparatus used in subjecting the heated test columns to the action of fire streams consists of a special four-inch hydrant located on each side of and approximately 26 and 39 feet from the middle of the furnace, about 25 feet of 2½-inch hose, and a standard play pipe provided with a 1⅛-inch nozzle and a pressure gauge tapped into its base.

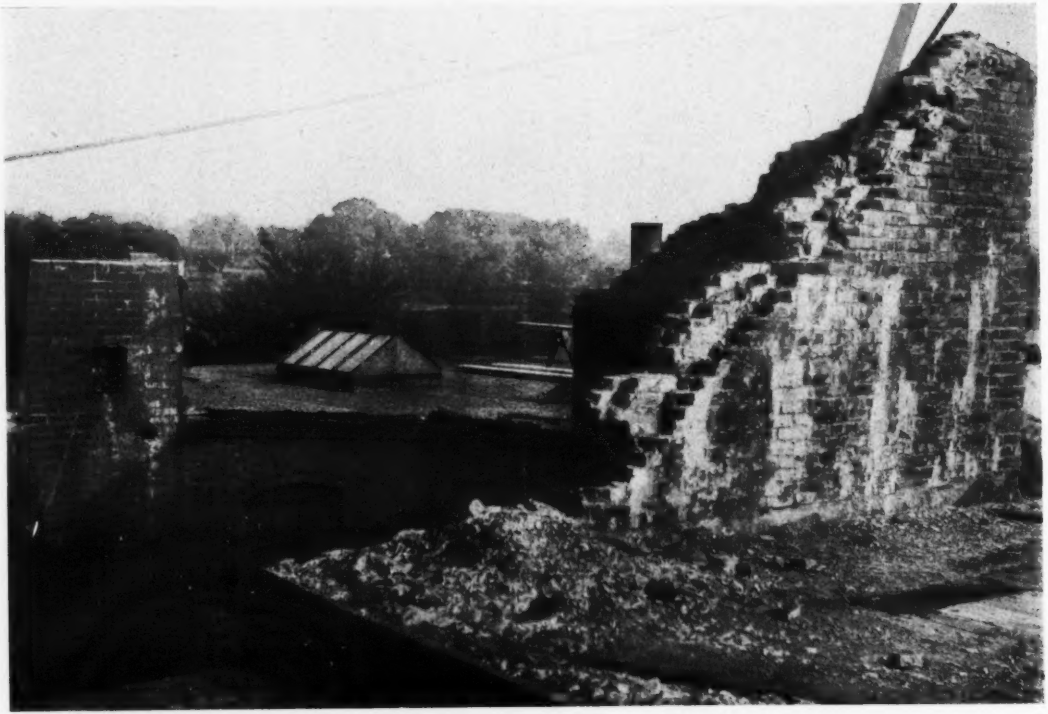
The hydrants are connected to a 6-inch underground main supplied by a pressure tank and an electrically-driven fire pump of 500 gallons capacity. The hose connections on the hydrants are provided with pressure gauges and 2½-inch hose valves.

# Gravity Tank Collapse.

**H-11264.** The gravity tank, secondary supply to this property, fell without warning at 11.30 a. m. on October 13th. This failure was apparently caused by the breaking of the top member of the tank support on the north side. This tank support was of poor design and had been neglected for several years, as frequently reported.

In order to properly describe the location of tank and its support, a description of the building is necessary. The building lies north and south on the east side of a canal. The main part is approximately square with a one-story machine room and boiler house on the east. Section "A", three stories high, extends across the south end and is sixty-five feet wide and fifty feet long. Section "B" is thirty feet wide and extends forty feet north on the west line of section "A". This is also three stories high. Section "C", basement and three stories in height, is twenty-one feet wide and extends forty-five feet north on the east line of section "A". The machine room, one story high, is forty-eight by one hundred and ten feet. It lies north and south on the east line of sections "A" and "C". In the area between the inner walls of sections "B" and "C" there was a one-story and part two-story section occupied by a forge shop and boiler on first, and storage of cut rags and lime tank on second floor. The boiler was charged from this room, which was over it.

The gravity tank was located over the building at the south end of this inner one and two-story section on line of north wall of section "A". It was supported as follows: The brick walls at southeast angle of sections "A" and "B" were extended about fourteen feet above the roof, each wall being twelve feet long and twelve inches thick. These walls acted as the west and south support of the tank. The north support, which also carried the east supporting beam of the tank, consisted of a four-foot brick pier twelve inches thick and about fourteen feet high, which extended from top of inner wall of section "C" on line with the north end of wall of section "B". The arrangement of timbers or supporting truss between this pier and wall on "B" was as follows: About one foot above roof line there was a ten by twelve-inch chestnut timber about eighteen feet long, which extended from pier to wall; about fourteen feet above this was another ten by twelve chestnut timber which extended from top of pier to top of wall; between these two timbers there were two braces of eight by eight spruce, poorly arranged and but slightly inclined. They had evidently been installed after the tank and were spiked to the upper and



*The Travelers Insurance Co.*

**Brick Walls of Tank Support after Collapse.**

lower beam. The east support of tank was a ten by twelve-inch chestnut beam which extended from east end of the twelve-foot wall on section "A" to the ten by twelve-inch top beam of the north support bearing on the top of truss about six feet from pier. Four by twelve-inch spruce timbers ran north and south on top of structure, forming a grid twelve by twelve feet upon which the tank was placed. This tank had a capacity of 7,100 gallons.

From the above it will be noticed that any settlement in the truss between the brick wall on "B" and the pier on "C" would also cause a settlement of the north end of the timber between the south wall of "A" and this truss, which would cause the tank to lean northeasterly. This is just what happened, and the breaking of the top beam at the point where the east supporting timber bore caused the tank to pitch northeasterly, striking the inner wall of "C" and demolishing the one and two-story section between "B" and "C". When the tank fell it threw the top of the west brick supporting wall on "B" westward onto the roof, in which it made an eight by twelve-foot hole. It also threw the south wall southward onto the roof, crushing a hole about fifteen by sixteen feet, and also one eight by ten-inch roof timber which lodged on top of a paper cutter,

*The Travelers Insurance Co.*

**Side of Building Crushed Out by Falling Tank.**

forcing one leg of this cutter through the ceiling of floor below. There was a girl working at this cutter when the roof timber collapsed. It broke a three-inch sprinkler connection and before the timber struck the girl the water had knocked her down so that she lay in front of the machine, and the timber lodging on top of the machine deflected the bricks so that she was only scratched on the arms by being thrown on the floor. The brick pier on the east fell in towards the tank, leaving about four feet standing. The tank falling northeasterly struck the inner (west) wall of section "C" about twenty feet from wall between "A" and "C" and crushed out approximately about eighteen feet of wall on third floor, twenty-two feet on second and twenty-four feet on the first floor. The second and third floors dropped from fifteen to sixteen inches in this space when the wall was broken down. The inner section over which tank was located was practically demolished. Section "B" was not injured. As previously mentioned the sprinkler system was crippled by the breaking of a three-inch connection. The debris of the collapse was carefully studied and the main beams supporting the tank identified. They were found to be badly rotted and to show signs of having sagged and cracked sometime before the collapse. The top beam of the north truss or support was broken off six feet from the east end at the point where the east beam would rest. The wood at this point was badly decayed on top, there being evidently a knothole there. The ends of the other beams were more or less decayed and considerable decayed wood was found in the beam pocket. The brick walls of tank support were found to be but eight feet high at the angle and one foot high at the roof line. The west wall showed there had been a crack and bulge in this wall previously, which had been reported by an inspector in 1914. The space under tank support had been enclosed but this was inside the truss so that the supporting structure had been exposed to the weather since erection. The age of the tank is not definitely known but it was probably built in 1900 when the sprinkler system was installed.

An employee of a bridge company working on the canal to the north said as he glanced toward the mill he saw the tank intact fall towards the northeast as if the northeast support had fallen. The tank turned bottom-side up in its fall. It was badly crushed by the bricks which fell from the wall but as far as could be determined was not a in serious condition before the collapse. Hoops were round and not seriously corroded. The mill property was in a poor and run-down condition. Roof planks were badly decayed. The tank had been leaking for several years and it is probable the structure was kept wet for many days at a time. It had been repaired, hoops tightened, and filled only a few weeks previous. It was miraculous that with the mill in operation only one person was slightly injured. There was little water damage as the water apparently all fell on the one-story part and ran through beater room to the river.

# Two Factory Fire Holocausts.

Within a fortnight of each other since the last issue of the QUARTERLY two factory fires involving heavy loss of life occurred in Pittsburgh and Brooklyn respectively. In the Pittsburgh fire at 207 Sandusky Street, October 15, 1915, thirteen working girls lost their lives and over a score were injured. In that at Brooklyn, No. 285 North Sixth Street, November 6, 1915, twelve persons lost their lives and thirty-eight were overcome by smoke and suffered injury or disablement by jumping. An official investigation into the causes and conditions of both these fires revealed the fact that in each of them culpable negligence and disregard of human safety were present. As an indication of the growing disposition on the part of the public to fix individual liability where such loss of life is the result of negligence, the coroner's jury in both cases brought in verdicts against those responsible. In the case of the Pittsburgh fire the jury found that the James Brown Estate and the Union Paper Box Company contributed negligence to the deaths, the James Brown Estate in renting a building for factory purposes, specifically declared in the permit for its erection to be used only as an office and warehouse, and the Union Paper Box Company in occupying such a building for factory purposes and in failure to hold fire drills as required by an act of the assembly. The president, the secretary-treasurer, and foreman of the Union Paper Box Company and the executor of the Brown Estate were held for the Grand Jury. In Brooklyn the coroner's jury returned verdicts against the proprietors of the Diamond Candy Company and the Essex Shirt Company charging them with manslaughter and holding each for the Grand Jury in $10,000 bail. The jury found that the locked trap door on the stairway between the third and fourth floors was responsible for the loss of life. We give below special reports upon both of these fires.

## PITTSBURG, 207-209 SANDUSKY STREET, OCTOBER 25, 1915.

**Special Report by Board of Fire Underwriters of Allegheny County.**

### Construction.

Building was four-story and basement, ordinary brick and wood joist construction, in good repair and occupied an area of 4200 square feet. Brick walls were independent and 16, 12, 12 and 8 inches. There were unprotected openings in all four walls, parapets on the rear and two side walls two feet high, with terra cotta coping; front wall two feet high with wood cornice on the brick wall. Roof was constructed of seven-eighths-inch wood, tongued and grooved, covered with composition. There was a frame pent house over elevator shaft 6 x 12 x 6 feet covered with composi-

Front of Building 207-209 Sandusky Street, Pittsburgh, North Side, showing opening to rear and collapsed fire escape at back, and stair entrance to Union Paper Box Co.

tion. There were no skylights. First floor was concrete supported by unprotected steel; the other floors were two-inch wood planks covered with seven-eighths-inch wood, except the stairway enclosure which was two-inch plank. The columns on the first three floors were 12 x 12 inches and the girders were 12 x 14 inches; the columns on the fourth floor were 8 x 8 inches and the girders were 8 x 12 inches, undressed lumber. The floor joists throughout were 2 x 12 inches. Floor openings consisted of two stairways, one from basement to first floor with two-inch wood trap; one from street floor to fourth floor, opening into seven-eighths-inch wood hallway with wood doors which were not self-closing. There was a wood and thin glass door into office on first floor. One elevator extending from the basement to fourth floor was enclosed in seven-eighths-inch wood shaft with wood doors on each floor which were not self-closing. There were five ordinary unprotected belt holes piercing fourth floor. The property was without division walls.

**Occupancy.**

Basement: Union Paper Box Company, storage of paste in barrels; Zenith Stove and Heater Company, storage of castings; James Brown and Company, straw and shavings in bales. First floor: Sigmund Paulet (office in N. E. corner of plant) harness shop, no employees; James Brown and Company, wholesale and retail feed dealers. Northwest portion of plant used as stable, four stalls, wood partitions. Second floor: Zenith Stove and Heater Company, assembling and manufacturing of gas stoves, floor heaters, etc., buffing and electro plating; lathes, drill press (operated by electric motors) gas furnace, etc. Five gallon safety can of benzine kept on window sill outside. Carboys of acid still intact. Third floor: Union Paper Box Company, manufacture of paper boxes; power machines operated by gas engine and electric motors; stock of finished boxes; cloak room and offices. Fourth floor: Union Paper Box Company, paper cutting machines and storage of cardboard and paper, piled to ceiling.

**Exposures.**

Front: Sixty feet to a three-story brick dwelling No. 210 Sandusky Street, with unprotected openings.

Right: Twenty feet to a two-story frame dwelling 102 Cairo Alley, with unprotected openings.

Rear: Forty feet to a two-story brick dwelling No. 34 East General Robinson Street, with unprotected openings.

Left: Three feet to a four-story brick hotel building, with two-inch tin clad shutters on openings.

**Hazards.**

Common: Electric power motors for elevators and machinery, also gas engine on third floor rear; gas and coal stoves; gas and electricity for lighting; small amounts of lubricating oils in metal cans on second and third floors.

Special: Carboys of acid on second floor for plating (still intact); benzine in approved can; small amount of waste, second floor; glue pot and hot plate on third floor (still intact); large doors for driveway from front to rear of first floor.

**Protection.**

Inside: Four approved three-gallon chemical extinguishers on both third and fourth floors; none on other floors. No standpipe nor hose. No alarm service nor night watchman.

Rear of building 207-209 Sandusky Street, Pittsburgh, North Side.
Fire escapes passing unprotected windows.

Outside: Fire escape on rear wall located over large doorway and passing wood and thin glass windows at all floors.

Public: Fire department protecting main business district of North Side.

### How Discovered.

About 1 p. m. John Clark, foreman of drivers for the Iron City Sand Company, who was in the habit of feeding his horse at noon in the rear part of the feed store, opposite portion used as stable, left the office to get his horse and discovered the fire. He immediately returned to the office, notifying the clerks.

### Origin and Spread.

Cause unknown. Fire was discovered in baled hay stored on floor south side of building, about thirty feet from rear and probably fanned by a westerly wind coming through the large rear doorway, and was driven toward the front burning its way through seven-eighths-inch wood stairway and then spreading very rapidly to upper floors through the open wood

**Pittsburgh North Side 207-209 Sandusky Street. Uncollapsed portion of premises Union Paper Box Co. showing congested condition of interior.**

hallway. The fire also spread to the seven-eighths-inch wood elevator shaft, carrying smoke and fire to upper floors. The fire was spectacular owing to the dense smoke caused by burning hay and paper. Fire was confined to the building.

**How Extinguished.**

Fire was extinguished by the public fire department. The first notice was a still alarm sent to the fire alarm headquarters at 1.10 p.m. over the telephone and immediately communicated to No. 46 Engine Company. An alarm from box located across the street from the building was pulled at 1.12 p. m. A second alarm was turned in at 1.15 p. m.; third alarm was turned in at 1.20 p. m. The above alarms called out engine companies Nos. 41, 42, 43, 44, 46, 47, 48 and 49 and trucks Nos. 12, 13 and 14. The fire was practically extinguished at 6. p. m. The water pressure was good.

There were probably ten hose lines which burst during the fire. This hose was purchased between the years 1904 and 1913. Smoke helmets were with the equipment but owing to the dense smoke they could not be used as the firemen could not get into the building.

**Damage.**

A large section of the second, third and fourth floors with contents (including roof over same) were precipitated to the first floor owing to the enormous weight of the water-soaked cardboard (stored on the fourth floor) and the weakened condition of the floor joists caused by the fire. There was heavy water damage caused to paper, hay, feed, sheet steel gas stoves and heaters.

**Loss of Life.**

Thirteen dead and a score injured. Death caused by suffocation, due to dense smoke from burning hay and straw.

**Conclusions.**

The loss of life and property in this fire demonstrates the importance of having all stairways and elevator shafts enclosed in a standard manner with approved, automatic fire doors on all openings; also of having stairways constructed of fire-resistive material, and of protecting in an approved manner all belt holes, pipe shafts, etc.

This fire strongly emphasizes the necessity of smokeproof towers which would in this case undoubtedly have prevented loss of life. Fire escapes on outside of buildings (where permitted) should have all openings exposing same protected by approved wired glass and metal frame windows provided with automatic self-closing devices.

Buildings should not be used for occupancies more hazardous than those originally planned for without further safeguarding of a character required by new uses and tenantry.

## BROOKLYN, 285-287 NORTH 6th STREET, NOVEMBER 6, 1915.

Special report by New York Chapter N. F. P. A.

**The Fire:** The fire originated on the first floor behind the elevator in the stairway enclosure where there were thousands of paper boxes stored. The first alarm was sounded at 1.44 p. m. As the engines responded, the Acting Battalion Chief, realizing the extent of the danger, dropped from his wagon a block away and sent in a second and third alarm. The evidence is conclusive that at least ten minutes elapsed from the discovery of the fire until the first alarm was sounded. The engines arrived, according to the testimony of Capt. Connelly, within three minutes after the call; the hook and ladder within four minutes; when the apparatus arrived "there was fire on all the first floor, and fire was coming out of at least one window on the second, and smoke was coming out of every opening in the front part of the building all the way up. There were 40 or 50 people on the fire escapes and the citizens were catching the girls as they dropped off the second floor balcony."

**The Building:** The area of the building was approximately 5,000 square feet, 50 feet front and 100 feet deep. The building had good brick exterior walls. Substantial wooden posts and heavy wooden girders supported the usual joisted floor construction, and single ⅞-inch flooring. The construction was open, except for metal ceiling on part of the first and third floors. Composition roofing was used, and the skylights were of wired glass in metal frame, including those over the elevator shaft as well as the one over the main building. The interior partitions were so slight as to be of no moment. The windows on the sides and rear of the building were of wired glass in sub-standard hollow metal frames having the upper and lower sash horizontally pivoted. The glass had a bearing of only ⅛ to ⅜ of an inch. All of the front windows including those opposite the fire escape were of wooden frame and sash with common glass.

**Exit Facilities:** (1) A stairway referred to as the "easterly stairway," some twenty feet in the rear of the elevator as one faces the building and adjoining the east wall. Beneath it was a flight to the basement. The entire stairway was enclosed in a light wooden partition, which in the first story extended in front of the elevator, forming a hallway to the street.

(2) A second stairway, referred to as the "westerly stairway," running from the first to the fifth floors adjoining the west wall. Its first story flight began some forty feet from the front wall and ran upwards towards the front. Above the first story it was in the westerly front corner of the building. This stairway was open, except at the third, fourth and fifth floor levels where there were non-automatic trap doors. The trap at the fourth floor level was bolted on the under side.

Fig. 1

General view of factory from the easterly side. Elevator shaft in the foreground. Note fused wire glass hanging from metal window frames.

Fig. 2

View showing part of front wall, and the fire-escape upon which employees crowded in their efforts to escape the fire coming through the windows behind them. Doorway and line of windows opening into elevator shaft are at the right but not shown in this view. Doors prevented lowering balanced stairway. Flames issuing through doorways beneath balanced stairway were an additional obstruction and peril.

(3) A fire escape of an obsolete type on the front of the building, having a balanced stair connecting the second floor balcony with the street.

**Elevator:** The elevator was for freight purposes. It was situated in the front right hand corner as one faced the building. It was enclosed in a 12-inch brick shaft, with metal framed wired-glass skylight at the top. The doors were two-ply metal covered, not standard, but of fair value. Apparently no one was employed for the specific purpose of operating the elevator.

**Occupancy:** The building was occupied, and had been since the time of its erection, by manufacturing tenants. As near as can be ascertained the normal occupancy was as follows:

Basement, first and second, Diamond Candy Co., employing 35 hands.
Third, Essex Shirt Co., employing 65 hands, but 90 sewing machines in place.
Fourth, B. L. U. Tailoring Co., coat makers, employing 37 hands, 24 machines.
Fifth, A. Baratz, manufacturer of shirts, employing 60 hands, 75 machines.

**How the Occupants Escaped:** On the afternoon of the fire there appear to have been in the building, fifteen persons on the first and second floors; sixty-five on the third, and ninety-seven on the fourth and fifth. Those on the first and second passed out of the building before the fire cut off their escape. Those on the third came down the westerly stairs to the second floor and, the fire being in possession of the first floor, either passed out of the building by means of the fire escape or to the roof of the low building on the left and so beyond danger. The ninety-seven employees on the fourth and fifth floors were shut off from any method of getting out of the building except by means of the fire escape. They were cut off from the easterly stairway by the fire, and from the westerly stairway by the trap door bolted at the third floor ceiling. The evidence is fairly conclusive that the employees worked for several minutes in an endeavor to force open the bolted trap door but failed. They only succeeded in securing a partial opening and through this some five persons squeezed. The fire escape therefore was their only means of descent and it had become over crowded. Its balanced stair had caught on a door which swung out beyond the front walls in the first story, and for some minutes this means of escape was blocked. Over crowding was also increased through fear of fire from the transom opposite this stair.

**Lives Lost:** Twelve persons lost their lives; eight by suffocation or burning, and four by jumping from the windows or fire escape. The eight were near or on the fire escapes of the upper floors.

**Persons Injured:** Thirty-eight persons were injured; some being overcome by smoke and many hurt by jumping.

**The Causes:** The causes which chiefly contributed to this disaster may be summarized as follows:

(1) The total inefficiency of one stair enclosure and the entire absence of another;

(2) The bolting of the trap door;

(3) Partial failure of the fire escape, due to overcrowding, lack of protection at openings, and obstruction of balanced stair;

(4) Storing of material in stairway;

(5) The failure to establish fire drills, and as a complement thereto a proper interior fire alarm;

(6) The failure to promptly send in the alarm of fire.

## RECOMMENDATIONS.

1. **Stairway Enclosures:** It is our belief that had the stairways been enclosed throughout with even the lowest grade of partition material permitted by the State Labor Department, the occupants of this building would have escaped in safety. We consider that the type of stairway enclosure which was in progress of erection on the third floor at the time of the fire and which is shown in Fig. 8, was not at all suited to the purpose. It is quite possible that such construction would not have been accepted by the Labor Department, but nevertheless we wish to register a protest against such construction, and the fact that it would not be acceptable should be so clearly understood by all factory owners that they would not even tentatively assume that it would be worth while attempting to "put it over." Sheet metal is a very poor resistant to heat, and when attacked by fire quickly becomes red hot. In that case it would instantly ignite the dry boards to which it is attached and would quickly fill the passageway with smoke and perhaps flame. We believe that if such low grade construction is permitted, a layer of asbestos board, plaster board or other incombustible, non-conducting material should be placed between the sheet metal and the wood work, or the wooden partitions should be properly covered with metal on both sides.

2. **Fire Escapes:** Existing fire escapes, even though they may not be brought up to standard, should be made less hazardous by the installation of fire windows opposite them and, as the law requires, there should not be any possible obstruction to their operation. The entrance to the fire escape, if possible, should not be made opposite the ladders and landing, but on an extension of the balconies to one side of the path of egress from the floors above, thus allowing the escaping people to avoid fire and smoke which might come through an open exit.

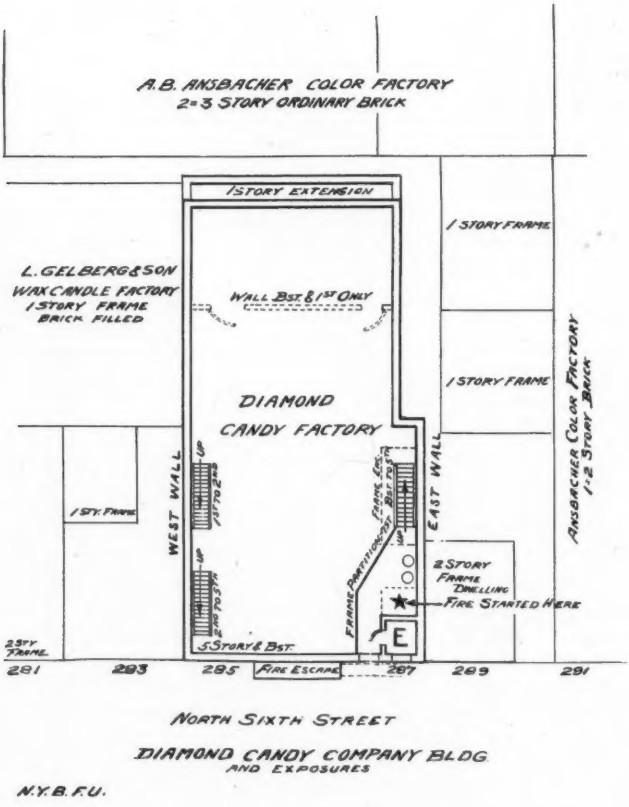



Fig. 3.

**Plan of factory building showing location of stairways, exit hallway, elevator, and fire escape.**

3. **Locked Exit:** We condemn most vigorously the practice of locking exits during working hours, and believe the punishment for such crime should be severe. In this particular case, considering the fact that reliable testimony shows that all occupants of the first, second, and third floors escaped, and that the fire did not render the west side of the building untenable for ten to fifteen minutes, it is probable that all the occupants of the upper floors might have escaped if the westerly stairway had been free. We believe that locked exit doors during working hours are inexcusable, as an automatic gong can easily be attached to give notice of the use of an exit. All exit doors should be readily opened without keys from the inside even though necessary to have them locked on the outside.

4. **Skylights:** Skylights over shafts extending through roofs should be glazed with plain thin glass which will readily break when attacked by fire, thus affording a vent, and preventing mushrooming of fire on upper floors.

5. **Storage in Stairways:** A more efficient method should be devised for preventing ignorant or indifferent people from violating the law by storing material in stairways.

6. **Automatic Sprinklers:** We believe that had this building been properly equipped with a system of automatic sprinklers, not only would the loss of life have been prevented, but serious loss of property as well.

7. **Fire Drills and Alarm System:** We believe that a properly organized fire drill, together with the necessary fire alarm system would have been effective in reducing if not entirely preventing loss of life, and we feel that a better method than now in use should be devised to secure the inauguration of proper fire drills suitable to varying conditions in factories. Frequent fire drills, using all exits, will tend to reveal inadequate means of egress and keep all exits in working order. They also help to give self control to occupants and make a tardy alarm less liable.

8. **Laws:** We believe that the present laws in this jurisdiction are adequate but that they should be simplified and clarified rather than amplified, and that concurrent authority should be avoided as far as possible.

9. **Criminal Negligence:** Indifference and negligence to comply with lawful orders for the safety of occupants is criminal and should be severely and quickly dealt with by law. It is interesting to note that the only orders complied with were those of minor importance which cost little, or those which had the direct effect of lowering the insurance rates on the building and contents.

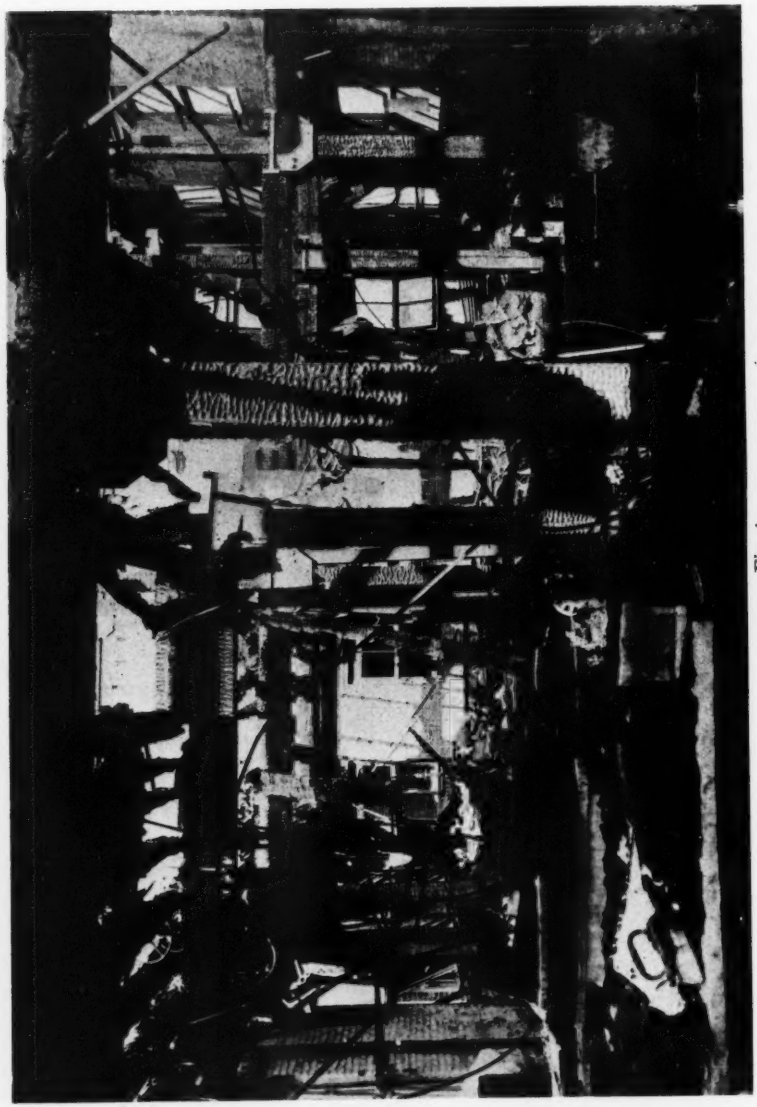


Fig. 4
General view of interior showing type of construction.

Fig. 5

View looking down at the locked trap-door in the 4th story floor. Door broken open by employees in their efforts to escape. Five known to have saved their lives by this means. Littered stairway leading to floor below is seen through opening in the door. Arrow indicates the bolt-lock still in place.

## DEPARTMENTAL ORDERS.

The orders issued by the various departments may be briefly summarized as follows:—

BY THE LABOR DEPARTMENT, March 12th, 1914, to the owner—

(a) "Provide counterbalanced stairs 22 inches wide from lowest balcony of fire escape to a safe landing place beneath; such stairs to have a pitch of 45 degrees;"

(b) "Fireproof all windows on the course of fire escape."

(c) "Fireproof all windows within 8 feet in a horizontal line of any part of the fire escape, balconies or stairs."

At the time of the fire Item (a) only had been complied with. Items (b) and (c) were subsequently suspended on the recommendation of the inspector.

January 2nd, 1915, to the owner—

(a) "Extend exit stairs to the roof."

(b) "Enclose interior stairways with partitions of fire resisting material."

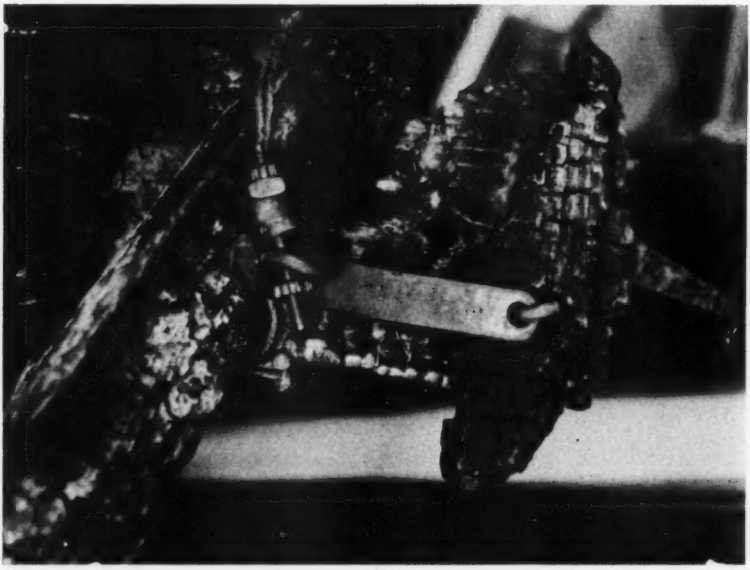


Fig. 6

**Detail of bolt-lock which was undoubtedly responsible for the loss of several lives.**

Neither of these items was complied with at the time of the fire, although the records show that various inspectors made seven subsequent visits to the building. The execution of order (a) was unimportant, but order (b) was vital.

January 11th, 1915, to tenant—third floor—

(a) Cease employing or permitting more than 60 persons to be employed or remain on the third floor.

This item was not complied with at the time of the fire, although the inspector reported it as a violation March 17, 1915 and again August 27, 1915.

January 11th, 1915, to tenant, fourth floor—

(a) Cease employing or permitting more than 60 persons to be employed or remain on the fourth floor.

This item was not complied with at the time of the fire.

January 7th, 1915, to owner:

(a) Extend exit stairs to roof;

(b) Enclose all interior stairways serving as a required means of exit, and the landings, platforms and passageways connecting thereto, on all sides with partitions of fire resisting material, extending continuously from the basement to 3 feet above the roof. All openings in said partition are to be provided with self-closing doors constructed of fire resisting material.

(c) Comply with Rule 380 of the Industrial Board.

## RULE 380.

"When, in addition to the required exits of any factory or factory building, there exist one or more outside fire escapes which are not entirely in accordance with the provisions of the Labor Law relating to fire escapes, such fire escapes may be retained without being changed to conform to such provisions, if steps are taken, satisfactory to the Commissioner of Labor, to prevent their use as means of egress, and provided that such fire escapes are maintained in good repair."

NOTE: The Commissioner of Labor has ruled that such fire escapes must be structurally safe and that they shall not be used for fire drills. At the openings leading to such fire escapes there shall be placed a sign, with letters 8 inches high, reading: **"This is not an Exit.** No barrier or guard will be permitted at these openings."

Items (a) and (b) were not complied with at the time of the fire.

Fig. 7

Stairway in 3rd story leading down from the locked trap-door; door removed before picture was taken. Portion of another trap-door can be seen beneath this stairway, also portion of inferior wood and metal partition which was being erected to enclose the stairway.

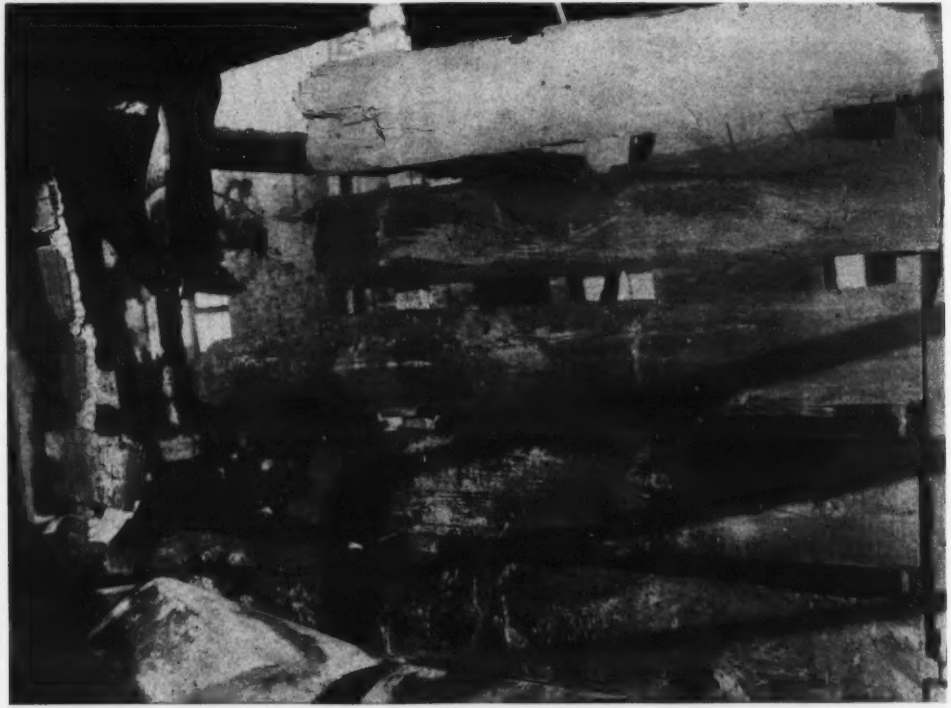


Fig. 8

Part of flimsy partition in process of erection at time of fire in 3rd story enclosing stairway. Note cheap quality of construction, 2 x 4 studs several feet apart, second hand lumber, with wide spaces between boards. The sheet metal which has peeled off is shown in the foreground.

BY THE NEW YORK FIRE DEPARTMENT, August 14th, 1914, to owner:—

(a) Provide a foundation for candy furnace on second story, constructed as per Section 87 of the Building Code;

(b) Provide a metal hood at least 9 inches below ceiling, for candy furnaces in the basement.

(c) Provide a metal shield on ceiling over gas jets in the basement.

These items were complied with and order dismissed by November 11th, 1914.

August 14th, 1914, to owner:—

(a) Remove smokepipe running through floor at first story and properly enclose the opening.

Complied with October 14th, 1914.

August 14th, 1914, to owner:—

(a) Provide a brick chimney for candy furnace in basement of building, constructed as per Sections 65-66 of the Building Code.

Complied with February 16th, 1915.

## CONCLUSION.

The several orders which were not complied with, though issued months previous to the fire, were in our opinion sufficient to have amply protected the lives of the occupants, had they been obeyed. The responsibility for lack of compliance appears to rest both on the owners and tenants who ignored them, and the authorities who issued the orders and failed to enforce them.

# Nitration Products of Cotton and Benzol

## MANUFACTURING PROCESSES, HAZARDS AND PROPERTIES. INCLUDING THE PREPARATION OF RAW MATERIALS.

By J. Albert Robinson, (Member N. F. P. A.)
Inspector Underwriters' Bureau of New England

## INTRODUCTORY.

The Chemical Industries and allied processes stimulated by the European War are of great interest at the present time.

A year and a half ago benzol could be had at 22 cents a gallon, and its manufacture and rectification was hardly considered by the fire prevention interests. Benzol is now selling at 80 to 90 cents per gallon and not long ago many orders were filled at from $1.25 to $1.40 per gallon. Its recovery from coal gas residuals of the gas works and the by-product coke ovens has evidently become a great industry, and it is in great demand, together with its homologue toluol as a raw product in a chemical industry, quite new to this country, at least on a scale of real commercial importance. In July, 1914, aniline oil was selling at 10¾ to 11 cents per pound while today one can sell it at 95 cents to $1.50 per pound according to the urgency of the consumer's requirements. Aniline salts, including picric acid which is now being made in large quantities, at present command $1.35 to $1.75 per pound, whereas 9 cents was the average price a year and a half ago.

Cotton linters was almost a drug on the market at three-fourths of a cent per pound. It rapidly moved to 4 cents and is now selling, together with cotton waste, at from 8 to 9 cents per pound. The country is now fairly dotted with a new industry, the purification of cotton waste, which is the raw product used in the increasing number of nitro-cellulose, or gun cotton factories, and for which a price of about 15 cents is obtained. It is in great demand by the Allied Governments and United States explosives plants. There has arisen a tremendous demand for acids, more especially sulfuric and nitric, which has necessitated the rapid erection of new buildings to furnish the incessent demand. The high cost and shortage of nitric acid has also stimulated the use of nitrates such as sodium nitrate (salt petre) in new lines of work.

The whole economic structure of the chemical industry has changed. The proudest discoveries of chemistry have been turned into means of

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relentless destruction and human slaughter. New manufacturing hazards have been developed, products are made that form the basis of violent explosives, of which little is known in this country, and the fire protection engineer or insurance underwriter is almost daily asked to pass upon some product or process, the name of which is strange and new to him. Factories recently vacant are found to be running night and day in the purification of cotton waste. Cotton mill manufacturers are found to be involved in the manufacture of gun cotton. Paper mills are found to be purifying cotton waste with great quantities of waste and linters on hand. Plants that advertise the manufacture of "coal tar intermediate products," a meaningless term to the layman, are found to be making picric acid.

Chemistry, however, must not be reproached with the fact that nitro-cellulose, of which the first application was to heal wounds and to advance the art of photography, has been perverted from these ultra-pacific purposes, for making smokeless powder and for loading torpedoes. Neither should chemists be blamed when phenol (carbolic acid), which revolutionized surgery, is turned from a blessing to humanity into a fearful explosive after it had been discovered that nitration changes it into picric acid.

These discoveries are not of recent date, however. Picric acid was discovered by Woulfe in London in 1771, and confirmed by Hausmann in 1788. Its identification as trinitrophenol by Laurent in 1843, and the demonstration of its explosiveness by Sprengel in 1873, began the era of strictly chemical explosives. Gun cotton and the cellulose nitrates were discovered by Schonbein in 1845 and Bottger in 1846. With the demonstration by Berthelot of the explosiveness of other nitro-substitution compounds than picric acid there came a widely extended and constantly increasing use for them. These nitro-substitution compounds are the explosives which are being made use of in the high explosive shells now working such devastation in the present European war.

**Subjects Treated.** This paper contains four distinct parts, divided into appropriate headings, as follows: —

PART I. THE PREPARATION AND NITRATION OF COTTON.

1. Purification of Cotton Waste and Linters.
2. Nitro-cellulose, Nitro-cotton or Gun Cotton.

PART II. THE INDUSTRY OF COAL TAR AND COAL GAS RESIDUALS.

Sources of Coal Tar and Gas Residuals.

Illuminating Gas, By-product Coke Ovens and Tar.

Important Coal Gas Residuals: — Benzol.

Benzol and Toluol Industry.

PART III. The Coal Tar Chemical Industry.
Raw Materials.
Fundamental Processes.
Synthetic Benzol Works. Phenol or Carbolic Acid.
Benzol Nitration Products.
Picric Acid, Trinitrotoluol, Nitrobenzene and Aniline.
Synthetic Color Works.

PART IV. Comparative Hazards of the Ultimate Products Previously Described.
Bibliography.

This paper does not include the manufacture of finished or complete explosives. It is to be assumed that explosives are made to explode, and that under the best of conditions this industry entails a great hazard. Nor is there any great demand for such information at the present time, for practically all the raw products more or less hazardous in themselves, to be sure, under certain conditions, entering into explosives that are being manufactured in this country, are being shipped abroad with a liberal percentage of moisture, varying from 10 to 30 per cent.

**Particular Hazards.** Thus far, fires from manufacturing hazards in these classes of risk in this country have been very few although a number of fires have occured, due to incendiary or other reasons. The experience of England and Germany will be referred to in Part IV.

One very important general hazard should be taken into account, which is also prevalent to a greater or less degree in other classes that are now busy with the manufacture of munitions of war or other so-called "war orders." This might be called "War Hazard." In all such works, but more particularly in the class of chemical works discussed in this paper, there obtains to a large degree, the hazard of a new and driving business, quickly established, frequently in a plant not originally designed, nor particularly well adapted to the business in hand; with a large shifting force of employees not yet welded together into a well disciplined and compact unit, and probably not apt to be, composed mostly of the cheapest class of foreign labor obtainable and subject to the irresponsibilities of that class; plant in operation day and night, the men most interested, frequently working to the point of exhaustion; manufacturing a product in demand by warring nations, on which an abnormally large profit is being made, but the demand for which may cease as suddenly as it arose.

This so-called "War Hazard" has also two other important features, the hazard of outside influences, which is thought to be very real, for certainly significant fires from unknown causes, have arisen in localities where manufacturing hazards were not present; and the hazard of unlicensed trespass about the premises and within plants where large quantities of readily inflammable or even highly explosive materials and products are present.

These hazards should be guarded by means of high fences topped with barbed wires, and rigidly guarded gates; regular yard patrol at night and even day time in the larger and more hazardous plants, with police or military organization and discipline; brilliant electric illumination about the yards and premises at night; and strict enforcement of identification methods for regular employees and properly endorsed permits for strangers in order to gain admittance on any business whatsoever.

Needless to say, smoking must be absolutely prohibited, and in many cases, all visitors or employees are relieved of matches at the office, and presented with a box of safety matches on leaving the premises.

**Interstate Commerce Regulations.** Since practically all shipments of finished product become matters of interstate commerce, the rules and regulations of the U. S. Interstate Commerce Commission, as applied to these products, based on data obtained by the Bureau for the Safe Transportation of Explosive and other Dangerous Articles, made binding upon shippers and common carriers under authority granted by Congress, have been of great value in reducing the hazard of the ultimate products of these war chemical factories.

The penalty of a possible fine of $2,000 and 18 months imprisonment is prescribed by law for a violation of these regulations. The shipper must certify on his shipping order that the Explosive or other Dangerous Article offered by him is in a proper condition for safe transportation and that it is packed and marked as required by the regulations. There are two general classes, I. Explosives, and II. Other Dangerous Articles. Under each class there is a list of prohibited articles and accepted articles. Of importance in connection with the subject matters of this paper, are the groups that come within the accepted articles of the second class, and the label required on the packages.

*Red Label.* This group includes any liquid or liquid mixture that gives off inflammable vapors at or below a temperature of 80° F.

*Yellow Label. Inflammable Solids.* This group includes all substances other than those classified as Explosives that, under conditions incident to transportation, are likely to cause fires by self ignition through friction, through absorption of moisture or through spontaneous chemical changes.

*Yellow Label. Oxidizing Materials.* This group includes all such substances as chlorates, permanganates, peroxides, and nitrates, that yield oxygen readily to stimulate the combustion of organic matter.

*White Label. Corrosive Liquids.* This group includes strong mineral acids and other strongly corrosive liquids that are apt to cause fires when mixed with chemicals or with organic matter, or are liable, in case of leakage from their shipping containers, to damage other freight materially.

Specific requirements necessary to allow a product to qualify for one of these classes, will be mentioned in connection with the product under discussion.

**Mixed Acids.** Nitro-compounds necessitate the use of large amounts of "mixed acids," consisting of strong nitric and sulfuric acids. The latter is used for the purpose of absorbing the water formed during reactions, so that the strength of the nitric acid will not be decreased and the nitration retarded or the desired degree of nitration reduced.

The usual commercial strengths of nitric acid are 38° (56.5 per cent), 40° (61.4 per cent) and 48° (91.4 per cent). "Dynamite Acid," is strong acid for making 96 per cent "mixed acid" (34 per cent nitric and 62 per cent sulfuric), used for nitrating gun cotton, nitro-benzol, etc. It was formerly necessary to have the nitric acid 93 per cent, but now that "oleum" is used, it need only be 88 per cent.

The commercial strengths and names of sulfuric acid are as follows:— Chamber acid, about 53° Be., (66.6 per cent); Commercial acid or oil of vitriol, 66° Be. (93.2 per cent) with boiling point of 533° F.; Concentrated acid, 98° Be. (98 per cent) with boiling point of 608° F.; Oleum or fuming sulfuric acid, 100 per cent charged with the gas of sulfur trioxide. Some manufacturers are selling 98 per cent acid as oleum. Oleum is used to revivify waste acids in nitration processes, which reduces very considerably the loss from excess waste acids.

# PART I.

# THE PREPARATION AND NITRATION OF COTTON.

A certain amount of nitrated cotton has always been made in this country both for the domestic manufacture of smokeless powders and in connection with the pyroxylin plastic business. For this purpose a different degree of nitration, or a less highly nitrated product has been customary. This product, some times called solvent cotton, collodion or pyroxylin, is a trinitrate and tetra-nitrate of cellulose. It is used in the manufacture of artificial leather, etc. The highly nitrated cotton, chemically known as hexanitrate of cellulose or tri-nitro-cellulose has not been commonly made and the utilizing of cotton waste and cotton linters as a raw product for nitrating plants has been almost unknown.

Since the outbreak of the European war however, there has been a great demand for gun cotton, and several large nitration plants have sprung up. These have demanded a tremendous amount of purified cotton waste, and this industry has been rapidly developed. There is even a demand for the purified cotton, unnitrated, across the water, and the purified waste is being shipped in carefully prepared bales of great density. Many paper mills are adding the purification of cotton to their regular work, causing a distinctly new hazard in this class.

## PURIFICATION OF COTTON WASTE AND LINTERS.

The raw stock which is being purified for nitrating purposes is composed largely of cotton linters. This consists of the short cotton fibres stripped from the seeds at the crushing plants. The ripest and cleanest fibre is desirable, and it is essential that the fibres be short as less pulping will be required later to open the cells in order to free possible acid secretions. This is a very important consideration. Immature and dead fibres removed during the cleaning of the fibre, and other such by-products are sure to vary in composition and do not give homogeneous reliable smokeless powders. Ordinary cotton waste from the first processes in the cotton mills is also used. Up to the present time, nothing beyond card waste has been considered suitable, owing to the difficulty of nitrating hard fibres and thoroughly freeing them from acid. Experiments have been carried on, which are said to be successful for treating spinning waste and even rags. For utilizing these cotton materials special preparatory machinery has been devised.

### PROCESSES.

**Receiving.** The cotton waste and linters is received in ordinary burlap covered compressed bales in a more or less delapidated condition. At some plants, and perhaps according to the condition of the raw stock, the cotton is first passed through a rough picker or carding machine. This does not generally appear to be necessary, and hand opening predominates.

**Washing.** In cellulose used for manufacture of gun cotton great cleanliness and purity is necessary. It is, therefore, washed and boiled in a dilute alkali solution, consisting of about one pound of caustic soda to every seven or eight gallons of water. The solution is drawn off and another boiling with fresh water is given the cotton. Besides its dissolving effect on impurities the alkali saponifies the oil and the soap formed removes the dirt. This is done in large wood vats, which may also be used as kiers in the next process.

**Bleaching.** The cotton is next bleached to remove lignin substances that form unstable nitrates. Large iron rotary bleachers are sometimes used. This is done with ordinary chloride bleaching powder or with calcium hypochlorite because of its cheapness. The latter material requires extra precautions in order to free the cotton of it. This is generally accomplished by washing the cotton for a sufficient length of time in an ordinary paper mill beater engine. The dirty water is taken out through the revolving drum screen.

Extreme care must be exercised in these two treatments to avoid severity lest there should be formed either oxycelluloses with their resulting unstable nitro-compounds later, or hydrocelluloses with their different rates of nitration.

After the thorough washing the cotton may be placed in stationary drainers for the surplus water to run out and then passed through a course or wet stock picker or disintegrater and then through a squeeze roll, where more water is pressed out. In some cases it is first forced between heavy rollers right from the beater engine, and pressed into wide felt-like sheets, after which it is subjected to an opening process. The first draining is frequently omitted. Sometimes a washer, such as is used in wool scouring plants, is placed between the wet stock picker and squeeze rolls, then the stock goes through a beater into the feed to the dryer.

**Drying.** Having been partially relieved of its moisture, the cotton may be blown to gauze rooms near the dryer or passed directly to it, as just described. The modern textile apron dryer, of all metal construction is almost universally used. These dryers should have sprinklers inside and be provided with steam jets, as well. As the cotton emerges with from 7 to 10 per cent of moisture, and since the temperature of the dryer does not generally exceed 160° F., there is not so great a likelihood of fire originating in them as in dryers where most of the moisture is to be eliminated. The cotton makes a slow journey through the dryer and is immediately baled up for shipment. It is frequently conveyed to a second story room and dropped through the floor to the bailing press. For domestic shipment bales have a density of about 25 pounds per cubic foot, or about 500 pounds total weight. For export, bales are compressed to about 45 pounds per cubic foot.

### HAZARDS.

The principal hazard of this process would seem to be from a large accumulation of fine dust or extra short staple cotton, about the dry end of the drying machine, and which seems to separate when the cotton emerges, or is handled in bailing. It is well to have the dry end of the drying machine enclosed in a fire resistive room, or the receiving room if the cotton is elevated to such. This dust should at least be cleaned up daily.

Cotton purification plants, of necessity will have a large amount of raw stock on hand, generally received in large lots, and the methods and location of storing and handling this product is of prime importance. It is common to find large quantities of yard storage without protection, which undoubtedly increases the hazard.

## NITRO-CELLULOSE, NITRO-COTTON OR GUN COTTON.

### PROCESSES OF MANUFACTURE.

The cotton nitration plant receives the purified cotton in bales and a large quantity will generally be found in storage. The cotton will contain from 7 to 10 per cent of moisture, and a preliminary process is necessary previous to nitrating.

**Drying.** The purified cotton, already scrupulously freed of all grease, oil, fat, lignin, dirt, etc., is first passed through a regular picker, then into gauze rooms to await the drying process. For this, the usual type of all metal textile apron dryers are used. They should be provided with automatic sprinklers and steam jets. The cotton must now be rendered as dry as possible, and a temperature of from 220° to 230° F., is found necessary. The cotton emerges with a moisture content of one per cent or less. The cotton may be 30 minutes in passing through, and as it becomes well dried out, under the forced heat, occasionally rather inconvenient but not seriously dangerous fires occur.

**Nitrating.** The nitration house, where the nitrating of cotton is conducted may vary in some details, but the essential characteristics will be the same. A typical nitrating house is a four-storied building with plenty of exits to outside fire escapes, plenty of windows to allow air circulation, and draft pipes sucking away the fumes from every fume-generating point. At some points, such as the neck of the nitrating pots, the suction of the draft pipes is shut off or opened by a valve connected to the lid; thus these draft pipes are opened only when necessary. The fumes collected are carried out and sent up a big terra-cotta standpipe, where they are condensed and collected for further use.

A nitrating house is divided into several separate nitrating compartments or units according to the total capacity of the plant. A nitrating unit has its parts on each floor of the building. On the fourth floor there is for each unit a vertical motor. The vertical shaft from the motor in passing down through the third story goes through the center of a square. in each corner of which is set one of four nitrating pots or earthenware jars The shaft connects on the second floor with the bottom center of an iron basket of a centrifugal wringer. On the first floor or basement is the submerging pot directly under the wringer

Each nitrating pot on the second floor has two agitators, interlocking with each other and revolving in opposite directions The agitators have a low and high speed, and are run by overhead shifting pulleys and belts connecting with shaft running lengthways of building and near the ceiling at both sides of the building.

The cotton ready for nitrating is fed by hand, from the end of the dryer, into a blower system, and is delivered on the third floor. The proper quantity is placed in a nitrating pot, and the requisite amount of mixed acids (nitric and sulfuric) run in on top of it, with the agitators revolving at the high speed. After thorough emersion has taken place the agitators are put on low speed. The composition of the acid mixture is of the greatest importance and largely determines the character of the product, that is, the proper degree of nitration. The ratio between the nitric and sulfuric acids and the water must be accurately adjusted. After nitration the nitro-cotton and the acid are drawn off by gravity from the pot, through a 6-inch pipe connected to its bottom, and run directly into, but against the side of, the slowly revolving wringer basket

underneath, which is then covered with a special lid. The centrifuge is speeded and the bulk of the acid still remaining in the cotton is flung to the circumference of the basket and runs through the holes therein and is collected in the basement below, or in an acid egg, from which it can be returned to the nitric acid department.

The acid wrung out, the wringer-man pulls up a valve plate, which surrounds the shaft and closes a circular hole in the bottom center of the basket. Through this hole with a brass-tipped pitch fork he works the nitro-cotton. It drops directly into the submerging vessel below, where each fork lot is suddenly submerged by a heavy stream of water. From here the nitro-cotton and water are pumped to the boiling tub house; or the submerging vessel may be in the form of a square lead lined wooden tank on wheels, which is trundled over to the boiling house on an industrial track. In some plants the cotton, after washing in the lead lined tanks, is again placed in centrifuges, before taking to the boiling house.

The wear and tear on a nitrating building is enormous. The presence of the acids and the fumes eat and corrode both wood and metals. Parts for renewal must be zealously kept on hand and constant vigilance maintained against the least sign of a breakdown. Automatic sprinklers are out of the question. A nitrating house in New England was equipped, but it was impossible to turn on the water. In fact it is becoming a problem to maintain the sprinkler equipment in the cotton storehouse, in a remote part of the premises, because of the fumes prevalent in the atmosphere, particularly under certain weather conditions.

**Boiling.** On leaving the nitrating house the submerged nitro-cotton is placed in boiling tubs, of about 1,200 pounds capacity. These tubs are located mostly below the main floor level, and have double bottoms, the uppermost one perforated and with perforated lead steam coils lying between. After draining off the submerging water and adding fresh, the nitro-cotton is given a number of boilings, perhaps five, by repeatedly adding fresh water, bringing to boil, draining off through the perforated bottom, and adding fresh water. The first boiling may be for as much as 30 hours, and the successive boilings for a less period, perhaps 5 hours. Dynamite-cotton receives an entirely different treatment, it being steeped in warm water and never boiled.

A certain amount of nitro-cotton is strewn about tubs on the floor of the building and becomes waste. It is collected and thrown into a tub by itself. In draining the boiling waters from the tubs through the perforated bottoms, material is again lost. Big settling troughs, through which the waste water is led, are built to collect this material.

After these boiling treatments the nitro-cotton is, after draining, forked out of the tubs into high-sided cars and delivered to the pulping house.

**Pulping.** The pulping machine is a regular paper mill beater engine. The beaters are set down in the floor, which makes it easy to dump the nitro-

cotton from the cars into them. During the course of the pulping of a charge enough sodium carbonate or soda ash, is added to make a slight alkalinity. The nitro-cotton is pulped from 8 to 12 hours according to conditions, and the nature of the product. Hot water is seldom used.

The washer connected with the beater carries off a good deal of fine nitro-cotton in liquid suspension. This liquid is run into large circular settling vats of iron. The waste from the floors is also dumped into these settling vats. The waste nitro-cotton that is collected from various sources is so fine that alum has to be used to insure its settling to the bottom of the vat. This fineness fits it particularly for the manufacture of sporting powders. It is essential that the high grade nitro-cotton be sufficiently fine to incorporate well in the mixing but not so fine as to clog seriously in the dehydration press, in the final manufacture of explosives. The recovered waste product may be blended with the regular product.

From the beaters the pulp filled water is pumped through pipes to the poachers.

**Poaching.** Poachers are large, deep, round wooden tanks with facilities for introducing steam into them, for draining the water from the top downward and for stirring the charge. These tanks have a capacity for 7,000 pounds of nitro-cotton when in a desirable thickness of water suspension.

When a poacher is first filled the charge is allowed to settle, the supernatant water drained off and clear water added. High grade nitro-cotton receives four five-hour boilings, with soda ash added to the first two. The stiring is kept up during the boiling. After the boiling, the high grade has ten cold-water washings. Dynamite-cotton receives these cold water washings only. Each washing is stirred for a half hour. All washings are run into the iron settling tank previously referred to.

Blending is partially carried out in the poachers. In fact it begins after the boiling, where a careful record is kept of every tub lot of nitro-cotton, which shows, by referring to the analysis of acid mixtures used, and also to the characteristics of the cotton, etc., about what percentage of nitrogen the nitro-cotton will have. In order to obtain certain definite and uniform results for a given kind of powder, predetermined weights of a known degree of nitrated cotton, are added to a poacher containing a known quality and quantity, and certain desired results obtained.

**Drying.** Centrifuges are used for the purpose of driving out the water. The rather thick solution of nitro-cotton and water is pumped into the wringer through a pipe line which has side connections easily handled by the wringer man. Again the waste water goes to the iron settling tanks. The water is thrown off until the product has not more than 30 per cent, or less than 20 per cent. The partly dried nitro-cotton is forked through the bottom of the wringer into a blending barrel, where the required final blending of different grades are brought together. When full the barrel is turned over a few minutes, opened, and the con-

tents dropped into a car, if there is a powder works in connection with the plant. Otherwise it is put directly into shipping boxes, or into a packing press, pressed into oblong blocks, then packed in the zinc lined boxes, for shipment, according to the specifications of the government buying the product. It must also conform to the requirements of the I. C. C., which limit the gross weight of the container to 400 pounds, and a minimum moisture content of 20 per cent. The container must be water tight. It is then acceptable for shipment with a yellow tag.

## HAZARDS.

Fires occasionally occur in the dryer. These are rather inconvenient but need not be considered dangerous. The dryers are all metal and should be provided with both sprinklers and steam jets. They should be cleaned out frequently so that there will be no accumulation of dried out cotton. If a fire occurs, all the charred cotton should be entirely eliminated from the process.for the presence of any carbon will cause unstable compounds when nitration takes place, and the batch in the nitration pot would probably fume off. It is also claimed that the cotton, once charred, cannot be successfully washed and freed from the carbon, and that all cotton thus contaminated, either purified or otherwise, becomes a total loss. The dried cotton as it emerges from the dryer should not be blown direct to the nitration house, but should be fed to the blower by hand. In some cases it is carried to the nitration department.

With exception of the nitrating and the possible drying of the nitrocotton (not required at raw product plants) the entire process after nitrating is worked with a large excess of water, and the probability of explosion thus reduced to a minimum. Among the more important precautions which should be observed may be mentioned: the careful extraction of the resinous and waxy matters from the cotton previous to nitration, or their thorough elimination in the boiling and poaching processes. Just as long as good clean cotton is used fires from this source will be a rarity. In the actual nitration process, the danger, except from acid burns, does not commence until the operation of wringing out in the centrifugals, and also in plunging the acid extracted nitro-cotton into the first wash water.

It is said that a minute drop of water dropped in a charge when in the wringer will cause a fire. It is not an infrequent occurrence for a centrifugal of the nitrated cotton to ignite and quickly disappear in a dense cloud of brown fumes of poisonous nitrous oxide gases which pass out over the premises. There does not appear to be any visible fire, or form of explosion but a rapid dissolution, with heavy evolution of gases. The men in the nitrating or extracting rooms rush for the outside balconies, and are rarely overcome. One of these occurrences was witnessed by the writer, just after having passed through the nitrating building. Even when a batch of nitrated cotton is not lost, considerable fumes are given off from the centrifuges during the operation, and a cowl with fan attached

for carrying away the fumes, is a necessity here. In England, His Majesty's Inspectors of Explosives no longer include in their reports cases where gun cotton has fumed off in acid centrifugals unless accompanied by personal injury, which is rarely the case.

The preliminary washing of the nitro-cotton in the vessel or tub below has to be done quickly and great care is necessary that the wrung-out nitro-cotton at once comes in contact with a large volume of water and that it is thoroughly disintegrated, so that the cold water entirely permeates the mass. If decomposition once starts, it is difficult to stop it, before loss of product results. The warmer the nitrated mass and the less volume of water, the more liable is it to decompose; hence on warm and damp days the centrifugals are more apt to fire.

It must be remembered that cotton is by no means a definite chemical body, and its physical state plays an important part in the nitration. With purified cotton coming from more or less inexperienced producers, it is not to be wondered at, that occasionally unstable nitration takes place. The important point is, and one that the chemist only can tell, whether unstable nitrates are apt to remain in the product, which may break down at some future stage, during the handling of the nitrated cotton during shipment, where great masses of gun cotton are present, or during its ultimate manufacture into smokeless powders or high explosives.

## PROPERTIES.

Nitro-cotton or gun cotton has an ignition temperature of from 356° to 374° F. It cannot be readily distinguished by outward characteristics from untreated cotton. On close examination a slight yellowish tint is recognizable. It is slightly rougher to the touch and crinkles slightly when pressed. When rubbed it is easily electrified and sticks to the fingers. When lighted, it burns with great rapidity, without smouldering or leaving any residue. It is insoluble in water, alcohol and ether. The explosive variety is a mixture of penta and hexa nitrate and contains from 12.6 to 13.4 per cent of nitrogen.

Gun cotton in the moist state is generally considered to be safe, but it can be easily detonated when a small primer of dry gun cotton is fired in contact with it.

# PART II.

# THE INDUSTRY OF COAL TAR AND COAL GAS RESIDUALS.

A hundred years of development have passed since Murdoch lighted the city of London with coal gas, and these years have placed gas lighting in the forefront of industrial progress. The history of these years plainly shows how the proper utilization of by-products can revolutionize the magnitude of an industry. The recovery of the valuable by-products such as tar and other residuals, and the extraction of valuable products from the gas itself, such as ammonia and benzol, both with a view of purifying the gas and for the utilization of products in the gas not essential for lighting or heating purposes, has proved a source of great revenue to the coal gas producer. The sale of these residuals has reduced the cost of production in a degree corresponding with the efficiency of the recovery methods adopted and the market value of the product. This business has proved to be a very important conservation of a great natural resource.

## SOURCES OF COAL TAR AND GAS RESIDUALS.

### ILLUMINATING GAS.

The most common source of coal gas residuals is from gas manufactured by the destructive distillation of coal and used for lighting purposes. The principal fixed gases contained therein are hydrogen, methane or marsh gas, ethane, propane, butane, etc., carbon monoxide, carbon dioxide, hydrogen sulfide, nitrogen, oxygen, and ammonia. The principal vapors in the mixture are benzol, toluol, xylol, and aqueous vapors. There is also formed coal tar which contains a certain amount of the same volatile constituents, together with creosote or heavy oil, phenol or carbolic acid, naphthalene, anthracene and pitches.

Most of the fixed gases are essential to the commercial product, and some are recovered in the regular processes of purification at the gas works. The greater portion of the volatile constituents are also essential, since the old and antiquated method of selling gas on a candle power basis still prevails, in many parts of the country. In order to enable the gas to keep this requirement a certain amount of benzol must be present in the gas, and under these conditions it is not practicable to remove much, if any of the benzol. The removal of benzol, however, does not depreciate the heat value of the gas, and by the use of the modern gas mantel, a clear blue flame from debenzolized gas will give perfect illumination. Owing to this custom of candle power standard, instead of the scientific

and practical method of heat value standard, most of the benzol recovered at the present time is from by-product coke-oven gas.

As a matter of fact, this country has largely discarded the older and more expensive methods of manufacturing retort gas generally used in Europe, for the less expensive and simpler water-gas process. This gas has to be enriched by the use of benzol, and it does not give any suitable gas tar.

## BY-PRODUCT COKE OVENS.

Competition, and the desire to produce gas and coke most economically, and also the tremendous demands of the great steel works for both coke and heat, brought an oven on the market called the by-product coke oven. This was a great advance over the old bee-hive coke ovens, in which the gases evolved are burned in the same chamber with the coal by the admission of air. This latter type of oven allows the valuable gases and tar to go to waste. In the by-product ovens air is carefully excluded from the charge, the heat necessary for the coking being imparted to the charge through the walls of the oven. The heat is supplied by the combustion of a part of the gases evolved, this part being carried through conduits in the sides of the oven and enough air being mixed with it to supply the oxygen necessary for the combustion.

**Types of Ovens.** There are two well known forms of coke ovens in general use, the Otto-Hoffman and the Koppers. The essential difference consists in the fact that by the Koppers system, each oven has its own recuperator and heating element, while with the older Otto-Hoffman system, there is a common heating chamber under a battery of ovens, and a single recuperator, or one at each end of the battery.

**Details of Construction and Operation.** The by-product oven, taken singly, is a rectangular chamber, from 16 to 24 inches wide, 6 to 12 feet high and from 30 to 40 feet long, and holds from 5 to 15 tons of coal. They are built in banks, or batteries of from 25 to 70 or more ovens in a battery. The division walls between the ovens serve as heating walls and contain either vertical or horizontal flues in which the combustion of the gas takes place. The air used for the combustion of the fuel gases is preheated in recuperators or regenerators and the products of combustion are then collected in a large flue and discharged through a chimney. All parts of the oven and conduits subject to heat are made of refractory brick.

Longitudinally along the top of the bank of ovens is laid, or carried by trusses, a track on which runs the larry or charging car, bringing the coal from the bin. The coal is discharged from the car and into the ovens through the charging holes. Upon one side of the battery are the wharf and track upon which runs the leveler and pusher, an apparatus which levels the charge of coal and pushes the coke out. On the other side is the quenching wharf, out upon which the coke is pushed and where it is

quenched with water. From this wharf the cooled coke is loaded into railroad cars or put in small cars on a trestle to be taken out to the coke pile.

By this process the by-products, tar and ammonia and the derivatives of the former are saved. The hot gases and tar which are generated enter the hydraulic main from which the tar is extracted, and the gases taken to the scrubbers and ammonia recovery plant. About 50 per cent of the gas is consumed under the ovens. The surplus gas, instead of being wasted into the atmosphere, is refined for illuminating purposes.

### COAL TAR.

This is the black, foul-smelling, oily mixture which separates from the gases formed in the destructive distillation of coal. The raw tar is composed of light oils, pyridine bases, phenols, naphthalene, anthracene, heavy oils, pitch, complex organic compounds insoluble in benzene, and known as free carbon, water, ammonia, and dissolved constituents of the gas. It varies greatly in composition and may be divided into retort gas tar and oven gas tar.

**Retort Gas Tar.** The retort gas tar is obtained as a condensation product in the hydraulic mains, scrubbers, or condensers, in the manufacture of coal gas for illuminating purposes.

**Oven Gas Tar.** This material is obtained as a by-product in the distillation of coal in retort or by-product coke ovens. It is similar to retort gas tar, except that it is more fluid. It contains more of the hydrocarbons and considerably less free carbon. The recent development in the United States in the use of by-product coke ovens has greatly increased the supply of tar and the recovery of its constituents by distillation.

The business of tar distillation has not been changed by present economic conditions, therefore the recovery of these valuable constituents and the use of pitch, etc., for the construction of gravel roofs and road binders, and in the manufacture of saturated roofing papers and felts, is not treated in this paper.

## IMPORTANT COAL GAS RESIDUALS.

### BENZOL.

Owing to the present great demand for phenol (carbolic acid), the natural product from tar is utterly unable to supply the demand. The business of synthetic manufacture of phenol from benzol has been developed, which, in turn has made a great demand for benzol, far beyond the ability of the tar distiller to supply. The direct recovery of benzol from coal gases has become of great importance. One ton of good gas coal yields about 10,000 cubic feet of gas, 1400 pounds of coke and 120 pounds, or 20 gallons of tar. Not over two per cent of this tar consists of benzol,

while 2 gallons of benzol may be recovered from the gas given off from the same amount of coal.

The introduction of the by-product coke ovens has made possible an almost unlimited supply of coal gas benzol. It is estimated that benzol is now being produced at the rate of 15,000,000 gallons a year in the big steel works alone, five times greater than before the war. The production of benzol as an industry, is here to stay and it is worthy of attention.

**Properties of Benzol.** Benzol is one of the hydro-carbon compounds which escapes with the gas produced during the dry distillation of coal, and owing to the fact that it is a low volatile it is retained in the gas at temperatures as low as 60° F., the other hydro-carbons being higher volatiles and therefore condensing at the various intermediate temperatures above 60°; the condensation of the other high volatile oils, however, dissolves and absorbes about 5 per cent of the total benzol contained in the gas.

Toluol, xylol, and some other high boiling compounds, such as solvent naphtha, are known as homologues of benzol, and these are found in the volatile portion of the coal and consequently in the resultant gas.

Benzol is a colorless fluid when freshly made and it greatly resembles gasoline. On exposure to air it soon becomes a pale straw color. Its specific gravity is 0.88, its boiling point 191° F, and its flash point 17.6° F., solidifying at 32° F., into large rhombic crystals which melt at 37.5° F.

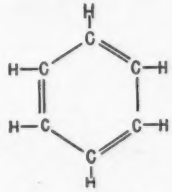
Pure benzol, or benzene has the chemical formula $C_6H_6$. A similar chemical product of the same formula is found in crude petroleum oil, and is known as benzine. This distinction in spelling should be noted.

These characteristics of benzol and its homologues only hold true for these products in chemically pure form, and considerable differences are found in the products as received from coal gas or tar, due to the fact that they exist as more or less of a mixture, and repeated distillations are necessary to even approach the pure article. The methods of recovery and purification to be explained later will produce the usual commercial product, the rectification for purity being left to the chemical manufacturer.

Commercially benzol is known as 50 per cent, 90 per cent and 100 per cent benzol, these consisting mainly of benzene and toluene, with small amounts of xylene. This percentage is not indicative of the comparative purity of the materials, but merely of the amount distilling at 212°F. The lower boiling benzols have the following approximate composition:

| | 100% Benzol | 90% Benzol | 50% Benzol |
|---|---|---|---|
| Benzene | 94-97% | 80-85% | 40-50% |
| Toluene | 2- 6% | 10-20% | 30-60% |
| Xylene | 0- 1% | 0- 5% | 0-25% |

The chemical formula for benzene $C_6H_6$ means that a molecule of benzene consists of six atoms of carbon and six of hydrogen. They have been found by chemists to be bound together in a peculiar way which can be graphically expressed thus:—



In writing equations this is usually represented by the plain symbol, thus:— The carbon atoms never leave the molecule, but one or more hydrogen atoms may be replaced by other groups to form other compounds. For instance, toluene $C_6H_5 \cdot CH_3$ is graphically shown thus:— the methyl group $CH_3$ having replaced one of the hydrogen atoms. When toluene is partially nitrated, a single nitro group ($NO_2$) is introduced into the ring by replacing a hydrogen atom and the product is known as mono-nitrotoluol, thus:— It is apparent that the $NO_2$ group might occupy other positions; thus:—

*o*-mononitrotoluol.

*p*-mononitrotoluol.

It has been found that such is the case and that three distinct forms of the mono-nitrotoluol can exist, with different physical characteristics. The various locations of these nitro groups are termed ortho, meta and para, the letters *o*, *m* and *p*, being ordinarily used. These several forms of the same molecule are called isomers.

**Uses of Benzol.** In general, the use of all grades of benzol, has been for solvents. They are excellent solvents for gums, resins, greases, rubber, etc., and it is mainly upon the wide and varied solvent power of benzol that the capabilities for their commercial utilization has rested in the past.

The present great impetus has been given the industry for the production of explosives, such as picric acid and trinitrotoluol. Aniline

oil and synthetic carbolic acid (phenol) has long been manufactured in this country in a small way for technical purposes, such as rubber compounding in case of the former, and as a basis of a line of so-called condensation products such as talking machine records, insulation materials, etc., in the case of the latter. The manufacture of phenol is an important step in producing picric acid. The natural supply of phenol is restricted in the coal tar recovery processes and its synthetic manufacture is becoming of great commercial importance.

Benzol and its homologues are readily converted into nitrobenzene and then into aniline, this forming a raw basic material which is used in the preparation of a long line of aniline dyes. Benzol also forms the basis for the production of artificial perfumes and in the preparation of pharmaceutical compounds, as well as in the production of saccharin, a substitute for sugar.

It is thought that benzol will find a ready market as an automobile fuel after the war. Careful experiments for automobile purposes show that benzol has a motive power about 25 per cent better than gasoline; it consequently would have 25 per cent advantage at the same price, so that even with benzol 25 per cent more in cost it would still be of equal value but experts state that with the present immense production, the cost has been reduced, so that it could be actually produced now and sold at the same price as gasoline if it were necessary to do so. It is a fact that the use of gasoline for automobile purposes is so large (100,000,000 gallons) that it is very difficult for the oil companies to produce enough to meet the demand.

## HOMOLOGUES OF BENZOL.

**Toluol,** $C_6H_5 \cdot CH_2$, so closely approaches the appearance of benzol that it is difficult to distinguish one from the other by ordinary means; its specific gravity is 0.87, boiling point 230° F, and solidifying point below −82° F.

**Xylol,** $C_6H_4(CH_2)_2$, is a combination of three products, closely resembling benzol and toluol and having a specific gravity of 0.87, the three boiling points being at 278.6° F, 282.2° F, and 287.6° F.

**Solvent Naphtha** is a compound made up of several hydro-carbons but their exact combination is only partially known. The name "solvent naphtha" is due to its very high solvent effect on rubber. It has a specific gravity of 0.87, and a boiling point of from 302° F, to 356° F.

## BENZOL AND TOLUOL INDUSTRY.

At the present time the removal of benzol from gas is of particular interest, and the process of removing and purifying benzol from by-product and other gases has introduced a distinctly new hazard at many coke plants and some gas works. The recovery of benzol, etc., from gas

is carried out in two principal steps, scrubbing or washing, and extracting or recovering. There are several systems for carrying this out but the general method and principles are the same, the difference being in the exact nature of the apparatus employed and the methods of procedure.

## METHODS OF RECOVERY.

After the gas has been cooled to the required temperature it is admitted into the benzol washers where it is brought into intimate contact with wash oils which at low temperatures are capable of dissolving out of the gas all the constituents which go to make up what is commercially known as crude or 50 per cent benzol, previously described. The wash oil containing the benzol will again release these constituents after being heated to about 266° F, and further separation takes place by distillation.

**Preparatory Work.** In plants where the ammonia is removed from the gas by the water absorption process, the gas usually has a temperature of from 68° to 100° F, while with the direct sulfate of ammonia system, the gas temperature is usually from 108° to 170° F. Since the method of recovering benzol requires a temperature between the limits of 68° to 77° F, the gas must be cooled before entering the benzol scrubbers if its temperature exceeds this figure.

**Scrubbing or Washing.** The wash oil, called "straw oil," at the works, is a petroleum product which is virtually a light machine oil, free from water, having a low naphthalene content, and a flash point of 300° F., or more. The gas is passed through one or more water tanks, then through several scrubbers, consisting of tall iron towers, through which the gas passes upward and encounters a downflow of straw oil. The oil may be sprayed, or spread out over the hurdles or trays contained in the towers. By thorough scrubbing it is possible to remove practically all of the benzol, etc., from the gas.

The scrubbed gas is passed through a drip tank, and then sent to the gas manufacturing division of the works to be burned under the ovens, sent to gas enriching plant, or direct to gas holders. The saturated wash oil, or "charged oil" is delivered to near-by storage tanks, from which it is pumped to a storage tank on the roof of still house, at the recovery plant.

**Extracting or Recovery Plant.** The processes in this plant are essentially the heating of the wash oil to drive off the absorbed benzol constituents, the recovery and cooling of the wash oil, and the separation, by distillation, of these benzol constituents to a greater or less degree. There may, or may not be present an elaborate rectification plant for recovering benzol of 90 per cent or more purity. In the ordinary separation of a light oil, or primary oil, 80 per cent benzol may be attained, and the secondary, or heavy oil, will contain toluol, xylol, etc. These oils may be shipped away for further refining at the plant where they are to be used.

The detailed methods of recovery vary, and an exact account of any one plant would not apply to all. The process is rather involved, but the fundamental features are about as follows.

In order to use as small an amount of steam as possible for heating the charged oil, methods of preheating are used. The cold wash oil enters a preheater, where it is heated to about 175° F., by benzol and steam vapors issuing from the still. This oil now passes through a second preheater in which it is preheated to a temperature of about 212° F., by means of the hot debenzolized wash oil issuing from the still. The lighter products of benzol begin to vaporize and leave the oil. It is then heated to about 266° F., by means of live steam in one of the superheaters for the purpose of driving off the water contained in it and thus rendering it possible to separate the naphthalene. The naphthalene is washed from the gas and absorbed by the oil in a manner similar to washing out benzol in the scrubbers.

At the temperature of 266°F., in the superheater, all benzol, toluol and water is expelled, and the oil with its remaining burden, xylol, solvent naphtha and naphthalene, now enters the still. The oil flows through the lower portion of this apparatus, the steam being blown directly into the lowest part of the still, thence traveling in a direction counter to that of the oil, thus driving off all xylol, solvent naphtha, and most of the naphthalene from the wash oil. The resultant mixture of benzol and water vapors passes through the upper portion of the still, where crude rectification is performed and where all entrained wash oil particles are separated from the vapors. The benzol and water vapors issuing from the superheater enter the upper portion of the still where they are rectified in conjunction with the other vapors.

These vapors now issue from the top of the still at a temperature of about 220° F., and enter the first superheater, previously mentioned, where they are nearly all condensed and the wash oil receives a preliminary heating. The remaining vapors and the condensates formed in the superheater now enter a water cooler, where the vapors are completely condensed and all condensates, water and light oils, enter a separator or decanter, where they are separated due to their difference in specific gravity.

The so-called light oil, or primary oil, is a mixture of crude and impure benzol, perhaps up to 80 per cent benzol, by some methods, toluol, xylol, etc., being also present. It is collected in a tank where it is stored for further fractionation and purification, or sent to storage tanks awaiting shipment. The water from the separator is led to the waste liquor tank where tarry matters may be collected and burned.

This recovered oil boils at from 122° to 248° F. The heavy oil or secondary oil, containing the bulk of the toluol, and other heavier ingredients, which boil between 248° and 302° F., may be separated at this time and no further rectification take place.

The wash oil, which has been freed from benzol, etc., leaves the still at a temperature of about 257° F., and enters the superheater previously referred to, where it transfers a portion of its heat to the charged wash oil, after which it enters the oil cooler, where it is cooled by water to a temperature below 77° F. It may pass over a series of circulation coils through which cold water is passing, arranged one above the other vertically, the oil flowing down over the whole coil, being caught in a trough at the bottom. The oil contains some naphthalene and a moderate amount of this substance vaporizes and is given off from the hot oil. A further amount collects on the pipes of the cooling coil where it is removed. It is essential that the wash oil be entirely freed from naphthalene, as its presence increases the viscosity and decreases the absorbing power of the oil.

A further distillation may take place and the various benzol products separated and sent to their respective storage tanks. Purification of benzol, etc., is accomplished by washing with sulfuric acid, caustic soda and washing and then distilling, for a final separation of the products, in their desired state of purity. This is generally done, where necessary, at the plant using these materials. From the usual by-product coke oven gases, about the following proportions of hydro-carbons are recovered:—benzol 67 per cent, toluol 16 per cent, xylol 8 per cent, and solvent naphtha 9 per cent.

**Toluol from City Gas.** The demand for toluol for explosives purposes may be greater than can be supplied by the amount of toluol recovered from coke oven gas along with the benzol, since there is less than one fourth as much pure toluol as there is pure benzol in coal gas. It is likely, therefore, should the demand continue, that city gas lighting plants may develop a system for removing the toluol only, since it is possible to extract a maximum quantity of toluol without materially reducing the illuminating power by candle power measure, or the calorific value of the gas. By using a limited amount of oil in the washers, very little benzol is extracted from the gas. Also, by using a prebenzolized wash oil for scrubbing the gas, that is, a straw oil having about 5 per cent pure benzol added, it is possible to extract nearly 80 per cent of the toluol contents, and leave more than two thirds of the benzol contents still in the gas.

A crude spirit is obtained, rich in toluol, xylol and naphthalene. By this means only a small amount of benzol has to be returned to the gas, and the plant for dealing with the saturated oil is small compared with that required when more wash oil is used, and a greater proportion of the benzol removed. By means of a carefully regulated plant, the general scheme being very similar to a regular benzol plant, a yield of about one third of a gallon of pure toluol per ton of coal carbonized is obtained, which in turn will make about four pounds of trinitrotoluol. It is stated that there is from twenty to forty times as much toluol in the gas made from a ton of coal, as there is in the tar produced from this bulk of raw material.

## HAZARDS.

There does not appear to be any additional hazard in the washing or scrubbing department. There is always the hazard of gas leaking in any gas plant, which in no way is increased by this work.

There should not be open fire of any kind in the still house. All electric wires should be in conduit, with outside switch boxes, and extra heavy, double enclosed vaporproof bulbs. The steam plant is apt to be at a distant point. Stills are generally provided with relief valves and all tanks have goose-neck ventilators, with wire gauze, to relieve the pressure. The gauze should always be present as a preventive against entrance of sparks. Inflammable vapors are present in weighing tank and decanters, and the necessary vents from these must be protected with wire gauze.

Storage tanks should be located in a large concrete pit, from which the contents may be syphoned. Discharge pipes ordinarily have a valve on the outside of the tank on the outlets. It is well to have another valve on the discharge pipe just inside the tank with an extension from it to top of tank so that it may be shut in an emergency if the regular valve leaks or fails. Storage tanks are also ventilated and wire gauze should be placed in the vents.

Product is shipped in drums or tank cars. While a tank car is being filled, locomotives should not be allowed to pass or even approach the locality. Explosions have occured in benzol drums and great care should be taken to see that they are free from vapors, and open lights kept from them, both at the shipping point and by the consumer. The drums should be thoroughly cleaned by steam being blown into them. One fatal explosion occured in England through carelessness in handling empty drums. At the time of the explosion men were engaged in welding a crack in a drum, and for this purpose were using an oxy-acetylene torch. As a result of the explosion the top of the drum was blown off, with fatal results. At the inquest it was stated that the drums were cleaned by rolling them up and down the yard.

# PART III.

# THE COAL TAR CHEMICAL INDUSTRY.

In the manufacture of synthetic organic materials and dyestuffs, a considerable number of products which have, in the past, been largely obtained from coal tar, are used as raw materials and it is for this reason that the business has been referred to as the "Coal Tar Chemical Industry" and that the dyestuffs so made have been given the name "Coal Tar Colors." It appears, however, from the facts presented in Part II, that this business is virtually founded on the residuals of coal gas and more particularly upon benzol and its homologues. From these valuable residuals, certain other very important organic chemical substances of complex character, the supply from natural sources of which is limited and not equal to present demands, may be synthetically produced.

Synthetic chemical manufacture is the art of producing a complex or compound chemical substance by separating certain groups or elements occuring in different chemical substances from their original combinations and recombining these separated elements into a compound identical with one formed in nature. Where this business is carried on without nitration, the class of risk has been termed "Synthetic Benzol Products." Where nitration products such as nitrobenzene, picric acid, etc., are made, the class of risk has been termed "Benzol Nitration Products." In the case of the so-called, coal tar color manufacture, both synthetic production of "intermediates" and their final nitration or chlorination, etc., into finished products is carried on, and such risks contain the hazards of the others to a large extent. These have been termed "Synthetic Color Works."

## RAW MATERIALS.

The principal coal gas and coal tar derivatives used in the synthetic production of organic chemicals are benzol, toluol, xylol, phenol, naphthalene, anthracene, and less important products from the so-called fatty acid series, methyl anthracene, phenanthrene and carbazol. The most important in the general industry are benzol and toluol which are now obtained from coal gases. The others find application in the manufacture of aniline dyes and pharmaceutical products.

The amount of benzol, its method of storing and the manner in which it is handled are of great importance. Benzol may also be rectified on the premises, and this adds a distinct hazard. Also large amounts of nitric, sulfuric and other acids will be used and they should be kept where the breakage of carbuoys or leakage from tanks will not endanger other products and form combustible combinations.

Other products and chemicals will be found such as wood and grain alcohol, several peroxides, and chlorate of potash, all of which should receive careful consideration as to their storage and use. Also iron in the form of powder, filings, drillings, etc., the presence of which may cause spontaneous heating and ignition of combustible material.

## FUNDAMENTAL PROCESSES.

The following six fundamental processes will be briefly described at this time. Sulfonating, caustic melting or alkaline fusion, nitrating, chlorination, reducing or amidation and alkylating. These processes are all found in the manufacture of aniline colors, and with the exception of chlorination, all are fundamental operations in the manufacture of synthetic phenol, picric acid, trinitrotoluol, nitrobenzol, aniline oil and dimethylaniline, and will be described in practical manufacturing detail under these headings.

**Sulfonation.** Sulfonation may be regarded as an operation by which an atom of hydrogen in an organic compound is replaced by the sulfonic acid group ($SO_3H$). If a single substitution takes place it is known as a monosulfonic acid. If this substitution is repeated two, three or more times, di, tri, or polysulfonic acids are obtained. The material to be sulfonated is treated with oleum, (98 per cent sulfuric or fuming sulfuric acid). As a rule, the amount of sulfuric acid taken is several times that required to do the chemical work, the excess acting as a vehicle. The excess sulfuric acid is as a general thing lost, either as a calcium sulfate or as a weak and highly contaminated sulfuric acid of which a part only can be strengthened up. It is, as a rule, run into the sewer.

Important practical applications of this process are described under the manufacture of synthetic phenol and picric acid.

**Caustic Melting or Alkaline Fusing.** Alkaline fusion is a process by which the sulfonic acid group ($SO_3H$) may be replaced by the hydroxyl group (OH). The substance to be subjected to the caustic melt is, as a rule, a sulfonation product. For example: benzol monosulfonic acid yields hydroxy-benzol which is phenol or carbolic acid. Naphthalene monosulfonic acid yields alpha-naphthol or beta-naphthol, depending upon which particular monosulfonic acid of naphthalene was used. The sulfuric portion reappears as sulfite of soda.

An important practical application of this process is described under the manufacture of synthetic phenol. This process calls for extreme care, and its success depends upon very minute details not always easily discovered. This procedure is carefully kept secret by the manufacturer.

**Nitrating.** Nitration may be considered as a process by which a hydrogen atom from the ring of an aromatic compound is replaced by the nitro-group ($NO_2$). As in sulfonation mono, di, or tri-nitro bodies may be formed according to the procedure used in nitration. Usually only mono-nitration is effected. Dinitrating and trinitrating are less frequently performed and are carried out through successive steps, as is described under the manufacture of trinitrotoluol. The differences are wholly of proportions, times and temperatures. The kind or quality of nitration product is not in every respect under control but quite generally the reaction can be "steered" in the right direction.

The material to be nitrated is treated with mixed acid, that is, a mixture of nitric acid with sulfuric acid. Water will always be formed during the reaction of nitration which exerts a retarding action owing to the resulting dilution of the acid. The most convenient method for avoiding the diluting effect of the water is to remove it as fast as it is formed, by carrying on the nitration in the presence of concentrated sulfuric acid which has a well-known affinity for absorbing moisture. The spent mixed acid in many cases can be re-strengthened so that there is only a slight loss of sulfuric acid.

Practical details of the processes of nitration will be described under the manufacture of picric acid, trinitrotoluol, and nitrobenzol.

**Chlorination.** The material to be chlorinated is treated with dry chlorine gas usually obtained from electrolytic caustic soda plants. As in nitrating there may take place mono, di, or tri-chlorinating and in addition the chlorination may be in the "ring" or in the "side-chain" according to the material, therefore, there may be six courses for the reaction to go.

This process is of interest to us because the products, although they bear a similar chemical relation to the nitration products, are diametrically opposite in their fundamental characteristics being inert and noncombustible bodies. A number of diazo-chlorides are formed by this process from which a large number of important derivatives known as the azo-dyestuffs are formed.

**Reducing, or Amidation.** As a rule only nitro bodies (the products of nitration) are reduced. The reduction of these bodies leads to very different products, according to the character of the reducing agents employed and the conditions under which the reaction is carried out. There are acid, neutral and alkaline reducing agents.

The most common acid reducing agents are metals, such as iron, zinc or tin in presence of a mineral or organic acid, the hydrogen liberated reacting with the nitro compounds yielding amido bodies. The most common example is offered by nitrobenzol which yields amidobenzol, otherwise known as aniline. The practical method of obtaining this product will be later described.

Neutral reducing agents include substances such as zinc powder and aluminum amalgam. Alkaline reducing agents are various, and do not act in the same way. Zinc powder and caustic soda convert nitro-derivatives into azoxy or hydrazo compounds.

**Alkylating.** This is the introduction of methyl or ethyl groups into hydroxyl group or into amido group. Methylation is generally effected by the use of wood alcohol and hydrochloric acid under pressure in autoclaves at high temperature. Sometimes methyl chloride will be used. Ethylation is similar to methylation, using grain alcohol instead of wood alcohol, and ethyl-chloride for the methyl-chloride.

Dimethylaniline is an important commercial product in the color industry which results from the process of alkylation.

## SYNTHETIC BENZOL WORKS. PHENOL OR CARBOLIC ACID.

Under normal conditions in the past the country's demand for carbolic acid or phenol has been amply covered by the amount recovered from the coal tar industry and the by-product coke ovens. Pure carbolic acid (or phenol, $C_6H_5 \cdot OH$) has found extensive application in the arts since its discovery by Runge in 1834. The aniline color industry employs it as an important intermediate product; together with its homologues, the cresols, it is extensively used in recent times for the manufacture of synthetic resins, and it is the starting material for salicylic acid and picric acid. It has long been a valuable disinfectant.

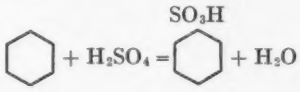
In this country, previous to the outbreak of the European war, synthetic phenol was produced in very small quantities, not because of our inability, but for economic reasons. Thomas A. Edison was the first seriously to feel the consequences of the complete cessation of importation of phenol from abroad. He uses large quantities in the manufacture of his phonographic disc records, which contain the artificial resin prepared from phenol, as binder and these are faced with a varnish of the same material. With the arrival of demand for high explosives from Europe the demand for phenol increased enormously. Mr. Edison at once began the manufacture of phenol and gradually other concerns began to prepare for the manufacture of this product.

The synthetic production of phenol from benzol is brought about by two fundamental processes of the organic chemical industry, namely: sulfonation and caustic fusion. The former comprises five distinct steps or operations, which involve three separate chemical reactions. The latter comprises three distinct operations and two chemical reactions. These are two fundamental processes in the aniline dye industry which have been briefly alluded to under the heading, Fundamental Processes.

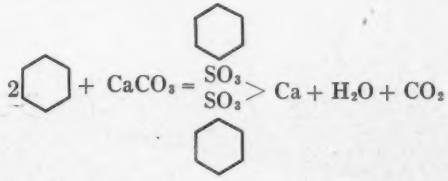
### MANUFACTURING PROCESSES.

**Sulfonation.** This consists of the sulfonation of benzol by strong sulfuric acid and is carried out in sulfonation kettles, consisting of a cast iron jacket kettle of about 300 gallons capacity, capable of being heated, either by water, steam or an oil circulating system, to about 176° F. The kettle may be provided with a bottom discharge. The lids must close tightly, a soft lead gasket having been found satisfactory. The lid is provided with man-hole, thermometer pipe, 4-inch opening for running in the charge, sometimes an emergency opening, and connection to a spiral reflux condenser, water cooled, for condensing the benzol vapors. The kettles are generally elevated to permit gravity discharge into the liming tanks. Owing to the great difference of the specific gravities of sulfuric acid and benzol, the tendency to separate into two layers and rotate as such, is very pronounced, and it is obvious that in that case chemical action is very much impeded. It is, therefore, necessary to have an agitator of particular construction.

In the cold or slightly warm kettle, the requisite weight, first of sulfuric acid, then of benzol is run in, then all the openings are closed, excepting that leading to the reflux condenser, and the agitator is started. The temperature soon rises to 140° F., or more. When the thermometer indicates no further rise, heat is admitted to the jacket, and from then until the end of the operation the temperature is maintained as closely as possible to the boiling point of benzol. The sulfonation requires from five to nine hours and is finished when the odor of benzol is practically gone. The result is benzene sulfonic acid, which separates in fair quantities, occasionally in crystalline form. The chemical equation is as follows:



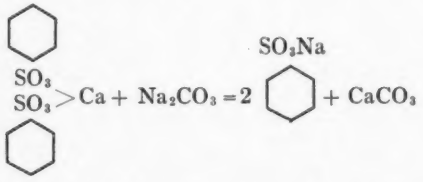

**Wet Intermediate Steps.** *Liming, or Conversion into Calcium Salt.* After complete sulfonation, the resulting mixture of sulfonic acid and sulfuric acid is run into about an equal volume of water contained in the liming tank. These are preferably wooden, lead lined tanks having a capacity of 1200 gallons, with powerful wooden agitators of the "gate" type, all iron parts protected and having a lead steam coil or an open steam pipe. There is a 4-inch bottom outlet, flanged and flush inside, proper draining being assured by a slight tilt. The bottom outlet is connected to a filter press pump. The milk of lime is prepared in a separate suitable vessel, with a straining device attached to the outlet. Milk of lime is run into the diluted sulfonation mixture, the latter being hot due to the hydration heat of the acid. Steam is turned into the coil when the milk of lime begins to run in. The milk of lime is added just short of the point where all the sulfuric acid and the largest part of the sulfonic acid is neutralized. Then sufficient calcium carbonate (chalk or sludge from the soda tanks) is added to neutralize completely. The content has now begun to boil and is maintained boiling for about 20 to 30 minutes. If it should become too thick, a little water may be added. The steam is then turned off and cold water equal to about one and one-half volumes of the original volume of the sulfonation mixture is run in. The result is calcium benzene sulfonate and calcium sulfate (gypsum). The chemical equations are as follows:




$$H_2SO_4 + CaCO_3 = CaSO_4 + H_2O + CO_2$$

*Separation of Soluble Calcium Salt from Gypsum.* The contents of the liming tub are pumped into a regular filter press, having two washing inlets, one at the bottom and one at the top of the plate, at a temperature of about 140° F., and the filtrate collected in the soda tubs. The cakes are washed, by means of the washing attachments, with hot water, the first washing being added to the filtrate while the last wash water may be turned back into the liming tub in place of pure water for diluting the sulfonation mixture. The amount of wash water necessarily depends largely upon the state and form of the gypsum precipitate, that is, if the same has been properly prepared and treated, comparatively little washing will be required, while on the other hand, if it has been allowed to become slimy, it is very difficult to completely remove the calcium benzol sulfonate from it.

*Conversion of Calcium Salt into Sodium Salt.* The filtrate and wash waters are run by gravity from the troughs of the filter presses into wooden tubs having a capacity of 1500 gallons. They may have a light stirring device, or the contents may be agitated by air or hand. They must have a closed steam coil of good size, in order to evaporate while filling, and to boil, which is necessary in order to obtain the calcium carbonate in the proper crystalline form. Dry soda ash is added until all calcium is precipitated. The calcium carbonate is allowed to settle, and the supernatant clear liquid, containing sodium benzol sulfonate, is fed to the evaporator. After the calcium carbonate has increased by several conversions, it is washed with water and then withdrawn and used for neutralizing the sulfonation mixture, or the whole solution may be passed through a filter. The chemical reaction is as follows:

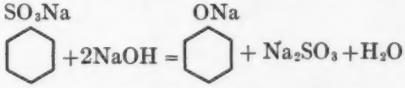



*Evaporation.* Evaporation of the sodium salt is carried out most economically in a multiple effect vacuum evaporator and the drying done in a vacuum oven. However, the temporary nature of this business, precludes the purchase of this expensive apparatus in all cases, and any means for evaporation and drying such as tanks with steam coils for concentration and jacketed shallow pans for drying may be found. The dry sodium salt is in the form of a dazzling, white, finely crystalline mass, which for the fusion, must be pulverized to a coarse powder.

**Caustic Fusion or Caustic Melt.** The caustic fusion of the sodium salt is carried out in open cast iron round bottom kettles, of about 300 gallons capacity, having an iron stirrer of the horseshoe type, which

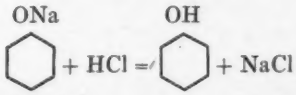
should as closely as possible approach the sides and bottom of the kettle. These pots are set in brick with arch construction to prevent direct contact with flame. The heating is by means of a fuel oil system.

The kettle is charged with the requisite amount of caustic soda and a small quantity of water, which facilitate the melting of the soda. The temperature is raised to about 320° F., and dry pulverized sodium salt of the benzol sulfonic acid shoveled in. When all has been added the temperature of the fusion is increased but must not be allowed to exceed 625° F. The fusion is complete when all the sodium salt has gone into solution, and the melt becomes thin. It consists of sodium phenate and sodium sulfite. The reaction is as follows:




*Dissolving the Fusion.* When still hot and liquid, the "melt" is ladled into shallow iron pans or trays and broken up after having solidified and cooled. This may be done with a crusher. It is then dissolved in water in a sheet iron cylindrical tank with conical bottom, similar to a benzol washer. It may be open but should be provided with a hood. A perforated false bottom, preferably arranged so that it can be lowered and raised and entirely removed, should be provided in the tank, and agitation provided by air. A lead pipe with perforated coil, a little above the conical end, serves for running in the acid, and the usual arrangement for withdrawing the liquid at the bottom and at different levels may be found.

*Acidification of the Fusion with Liberation of Phenol.* When the cakes of sodium phenate are dissolved diluted sulfuric or hydrochloric acid from a lead lined storage vessel is run in until the beginning of copious evolution of sulfurous acid indicates the beginning of the decomposition of the bisulfite. The contents of the tank are now allowed to stand, the aqueous solution containing sodium sulfate or chloride, according to the acid used, and sodium bisulfite, is subsequently withdrawn at the bottom, and the phenol freed from sulfurous acid by vigorously blowing air through it for some time. The reaction with hydrochloric acid is as follows:




**Distillation of Crude Phenol.** The resulting crude phenol is now distilled from a phenol still and gives, after removal of the forerun, pure crystalline phenol of the highest melting point. The yield is about one pound of phenol for one pound of benzol.

The characteristic odor of phenol can be readily detected and its presence made known if for any reason, there was any intentional attempt to conceal the fact.

### HAZARDS.

The hazards of manufacturing synthetic phenol are chiefly in the sulfonation process, where benzol is added to strong sulfuric acid. Unless the heat from this reaction is controlled, there will result a too energetic ebullition of the benzol which will pass out through the condenser. This vapor is of course readily inflammable, and would be ignited from any open flame. This process should be in a building by itself or cut off from the remainder of the plant.

The caustic fusion pots are generally heated by a fuel oil system, which should be approved and the usual precautions for such a system taken.

### PROPERTIES.

Phenol, Carbolic Acid, or Hydroxy Benzene has the formula $C_6H_5 \cdot OH$. Phenol crystallizes in colorless, deliquescent prismatic needles of characteristic odor. It has a melting point of about 108° F., and boils at about 361° F. In contact with air it slowly becomes pink. Phenol is highly poisonous, and has a strong caustic action on the skin, quickly causing blisters. It is a powerful antiseptic, germicide, and disinfectant. It dissolves freely in most organic liquids but is somewhat soluble in water. Phenol liquifies on the addition of 14 to 15 per cent of water, and is then known as No 4 Carbolic acid of commerce. It is also sold in glycerine solution. It is volatile in steam, but the vapor is not thought to be combustible. Phenol burns with apparent difficulty, giving off a heavy smoke or unconsumed carbon.

## BENZOL NITRATION WORKS.

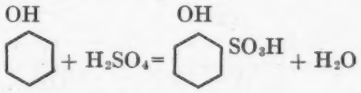
### PICRIC ACID.

Up to a year or more ago, the manufacture of picric acid in this country, at least outside of the recognized explosives industries such as the Du Pont's, etc., was practically unheard of, and the material itself was seldom found. Small quantities were used as a dye and as an intermediate product for other colors. Since the outbreak of the European war, there has been a great demand for picric acid and the business has sprung up in several quarters. Up to the present time most plants making picric acid have made their own synthetic phenol, substantially as described under the previous heading. Several plants now propose to make picric acid from phenol bought in the open market.

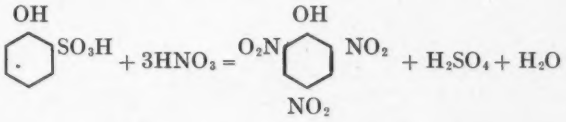
Picric acid is known at the works as "P.A.", or "T.N.P."

**Manufacturing Processes.** *Sulfonation.* A large sulfonation kettle of the usual construction, preferably lead-lined, with steam jacket, bottom discharge and agitator, is charged with one part phenol and four parts 98 per cent sulfuric acid. The phenol is previously melted on some form of hot plate heated by steam. The mixture is heated under agitation

until a sample shows by the required characteristics that phenol sulfonic acid has been properly formed. This product is solid at ordinary temperatures. The reaction follows:



*Nitration.* The phenol sulfonic acid is put into the nitrators of which there will usually be quite a number. These are receptacles of earthenware suspended in a space adapted to have hot or cold water circulated therein. The special arrangement of these nitrators may be worked out in several ways according to the special ideas of the manufacturer, the details of which are considered confidential. To the content of each kettle an equal part of sulfuric acid is added, and after reducing the temperature to below 68° F., the nitrating acid is run in. The nitrating acid is the usual mixed acid. Sodium nitrate (saltpetre), may also be used for nitration purposes. The temperature is kept low while the first of the acid is run in and then gradually increased to from 158° F., to 176° F., hot water being circulated toward the end of the operation and one to two hours afterward. Proper ventilation must be provided. Air may be blown through the nitrators before removing their content in order to remove the nitrous gases formed. Nitric acid recovery towers are located outside. The nitration reaction is as follows, the product being trinitrophenol, or picric acid:



*Crystallization.* The contents of the nitrators are now removed to wooden vats (non-metallic and acid-proof linings being essential), and diluted with water, about equal volumes having been found to give the best results. After cooling, the picric acid which separates usually in large crystals, is filtered by means of centrifuges, and washed. It is necessary to guard against the formation of too large crystals and "caking." Theoretically a yield of 230 pounds of picric acid should be obtained from 100 pounds of phenol. Practically from 150 to 175 pounds is obtained. The spent acids are usually kept and concentrated for use again in the process. The finished product is packed, with a moisture content of 15 to 20 per cent in barrels lined with water-proof paper. The rules of the Interstate Commerce Commission require that the moisture content shall be not less than 10 per cent, that the gross weight of the package shall not exceed 400 pounds and that the packages be water-tight. It is then accepted with a yellow tag.

**Hazards.** The principle hazard of the nitrating process is present where nitre is used instead of nitric acid. The storage of nitre and disposition of the nitre bags becomes important. There does not appear to be any particular fire hazard in connection with the nitration itself. Owing to the objectionable fumes of nitrous oxide given off, it is generally isolated from other buildings. The sulfonation of the phenol may be by itself although no hazard is recognized in this process, steam being about the only vapor given off. The odor of phenol, however, is noticeable.

The drying and pulverizing of this material is a hazardous operation. This is seldom required in chemical factories, the ordnance works and European governments accepting delivery of the wet crystals with a moisture content of 20 per cent or more.

**Properties.** Picric acid or trinitrophenol, $C_6H_2(NO_2)_3 \cdot OH$, presents pale yellow crystalline leaflets of exceedingly acrid taste soluble to about one per cent in cold water, more readily in hot water and easily in alcohol and the usual organic solvents. Its melting point or fusing point is variously given as 248° F., to 252.5° F. The specific gravity of the latter is from 1.63 to 1.67.

Ignited it burns without explosion but is readily detonated by fulminate of mercury or gun cotton and is one of the most powerful of explosives. It may be detonated in the wet condition according to some authorities, and is said to be used in this condition in some forms of explosives. It is introduced into shells in the molten or fused state. It may be pressed under hydraulic pressure into very hard shapes. In this form the P.A., may be drilled and worked safely. In the fused state it is variously known as "melinite," lydite, roburite, shimose, etc. Many metallic salts of picric acid are said to form violent explosions, and for this reason wooden vats and earthenware crocks are used in the processes of manufacture. The picric acid salts of sodium, potassium and ammonium are particularly hazardous and used in explosives.

Picric acid may be used for dyeing wool or silk, but not cotton. Silk dyed with this material especially takes a beautiful yellow color. The shades obtained however, are not very fast to washing or light, hence, picric acid is rarely used except in small quantities and in admixture with other dyestuffs.

**The manufacture of picric acid may always be detected by the yellow stains on the hands and even face, the yellow tinged hair and yellow shoes of the employees, and the general appearance about the plant. A picric acid plant, once seen or understood, can never be mistaken.**

## TRINITROTOLUOL.

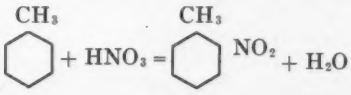
Trinitrotoluene, generally referred to at the works as T. N. T., and variously known as trolite, trilit, trotyl, trinol, tritol, tritolo and toulite, is obtained from toluol by a process of nitration occurring in three successive stages and involving the intermediate formation of

mononitrotoluol and dinitrotoluol. The extent to which the nitration may proceed to any one of the above stages is controlled by conditions of treatment and particularly by the factor of acid concentration. This can be regulated by adjustment of the quantity of nitric acid employed and also by varying the amount of sulfuric acid mixed with the nitric to take up and render inactive the water which is one of the reaction products.

**Manufacturing Processes.** In commercial practice, the nitration may be accomplished, either in one stage or in several successive stages. The simple stage process of nitration is the simplest in operation and requires a minimum investment in plant and equipment. It has the disadvantage, however, of being uneconomical in acid at the end of the reaction and the resulting spent acid cannot be utilized, although its strength is considerably greater than would be necessary in the earlier stages of the other process. This method has not been observed by the writer and is not thought to be prevalent.

The usual method of manufacture involves three stages of nitration, the reactions being brought about in large iron autoclaves or nitrators, arranged in sets of three through which the materials pass during the three successive nitrations. These nitrators are provided with various inlets and outlets. Also pipe coils through which water circulates to control the various temperatures of the several reactions, and ventilation for removing the fumes of nitration and relieving the pressure.

*First or Mono-Nitration.* A mixture of 180 parts by weight of pure toluol, 315 parts of sulfuric acid (Sp. gr. 1.84) and 200 parts of nitric acid (Sp. gr. 1.44) are brought together in the first nitrator under proper temperature control. The chemical reaction is as follows:




This mononitrotoluol exists in three isomeric forms, and direct nitration of toluene yields a mixture of these isomers, containing but little, however of the middle one. These forms are ortho, meta, and para mononitrotoluol, and are shown in Part II.

The physical properties of these compounds are as follows:

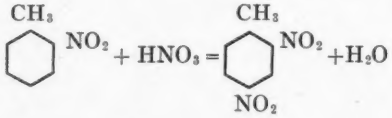
| | Melting Point | Boiling Point | Specific Gravity |
|---|---|---|---|
| Ortho | 50.9 Fahr. | 424.4 Fahr. | 1.168 |
| Meta | 60.8 " | 447.8 " | 1.168 |
| Para | 129.2 " | 460.4 " | 1.231 |

*Second or Di-Nitration.* The waste acid is drawn off from the retort, and a fresh acid mixture of 600 parts of sulfuric acid (specific gravity 1.84) is added which transforms the mono-product into dinitrotoluol. The mixture is heated and stirred during the operation and

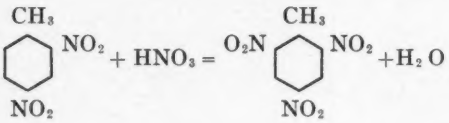
the dinitrotoluol separates as an oily layer from the hot mixed acid. The latter is used again for making the mono-product. Dinitrotoluol forms, on cooling, a pale yellow, fibro-crystalline, moderately hard and brittle mass. It exists in six possible isometric forms, which are all solids. These are designated by numbers, the position occupied by the methyl or $CH_3$ group being No. 1. The melting points of these various dinitrotoluols are as follows:

| | 2:4, | 3:4, | 2:3, | 2:6, | 3:5, | 2:5 |
|---|---|---|---|---|---|---|
| The melting points Fahr. | 158.9, | 190, | 145.4, | 141.8, | 199.4, | 126.5. |

The dinitrotoluol produced by the nitration of the commercial mixture of *o*- and *p*- nitrotoluol consists chiefly of the 2:4 and 2:6 products. The chemical reaction by which the 2:4 is produced may be shown as follows:



*Third or Tri-Nitration.* The dinitrotoluol is now dissolved by gently heating it with four times its weight of sulfuric acid (96%) and it is then mixed with one and a half times its weight of nitric acid (90-92%)- the mixture being kept cool. Afterwards it is digested at 194 to 203° Fahr., with occasional stirring until the evolution of gas ceases, which takes place in about 4 or 5 hours. The product, after cooling is separated and washed Although T. N. T. is theoretically capable of existing in six isometric forms, only three have been prepared, 2:4:6, 2:3:4 and 2:4:5. The former, or symmetrical compound is the chief constituent of the commercial product. The chemical equation is as follows:



This process of making T. N. T. which involves three stages of nitration, with complete or partial purification of intermediate products, is expensive as regards cost of plant equipment and labor. It does, however, permit economic utilization of acid, since the spent acid from the final stage may be employed in an earlier stage, obviating the necessity of discarding any but a thoroughly exhausted waste acid. The nitrous oxide fumes given off during nitration are caught and conducted to outside towers of tile, where nitric acid may be recovered.

Under the present exigences of the market, specifications do not call for recrystallized final product. It has been found possible to obtain the desired degree of purity by a simple process of washing and drain-

ing, providing conditions of preparation have been carried on under proper control. The finished product is packed with 20% or more moisture, in barrels lined with waterproof paper. The rules of the Interstate Commerce Commission require that the moisture content shall not be less than 10%, and that the gross weight of the package shall not exceed 400 pounds, the package to be water-tight. It is accepted with a yellow tag.

**Hazards.** In making T. N. T. great care has to be taken to purify the toluol, since that usually found in commerce contains benzene and other compounds. As in the case with all nitro-compounds of the hydrocarbons, decomposition and even fire may occur during nitration if the reaction is allowed to proceed too vigorously. Volatile fumes may be given off and free tuluol escape making mixtures of explosive vapors. Explosions have been reported in German plants, occuring in the nitrating apparatus. This may occur if there is any stoppage in the circulation system which controls the temperature of reaction. This should be operated under efficient control. Explosions have also occurred after nitrator has been allowed to cool down over Sunday or for some other cause during the process of nitration. In order to start the reaction more acid than is proper, is poured in. When the temperature rises the balance is upset and trouble arises.

An explosion, or vapor fire occured January 2, 1916, in a New England plant manufacturing T. N. T. It was noted by the Superintendent that the temperature was abnormally high in the third, or tri-nitrator, containing dinitrotoluol which was just passing through the third nitration. He immediately tested the outlet pipe from the circulating coil and found steam issuing. He saw at once that there was a stoppage of some kind in the circulating coil and left the room to send for a mechanic. Immediately thereafter he heard a dull roar and the whole building was enveloped in a sheet of flame, which soon subsided. The top of the nitrator was blown off and the roof and walls partially destroyed. Very little fire ensued, the timber supports for the nitrating autoclaves being intact. Investigation developed the fact that the water had not been in circulation for some hours previous at the mono- and di-nitrators. The night had been cold, the fire occuring shortly after 9 A. M. It was concluded that the circulation pipe became frozen.

As a result of this fire, which showed the necessity for careful temperature control, and a certainty of flow in the circulating pipe, it has been proposed to introduce a glass sight in the inlet pipe, through which the flow of water may at all times be observed. There was a large quantity of raw T. N. T. in a wooden tub in the building at time of fire. The tub was charred but the T. N. T. did not ignite.

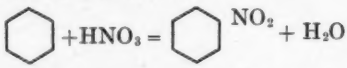
**Properties.** Trinitrotoluol has the formula $C_6H_2(NO_2)_3CH_3$. The melting point of pure 2:4:6, T. N. T. is 177° F.; of the 2:3:4, 233.6° F.; of the 2:4:5, 219.2° F. Pure 2:4:6 T. N. T. is a white solid of absolutely neutral reaction and of unusual stability. The commercial

product is generally a pale yellow and has a melting point of 167° F. It is practically insoluble in water, either hot or cold. It is sparingly soluble in cold alcohol, but readily in hot, this solvent being one commonly used for the process of recrystallization. T. N. T. is non-acid and does not combine with metals to form explosive salts. The product is free from danger of deterioration. T. N. T. is one of the most valuable of explosives used in military service for bursting charges, yet it is sufficiently inert so that the possibility of accidental explosion through concussion is practically nil. It is stated that a shell filled with it may be made to penetrate steel plates without setting off the explosive through shock. Detonation is accomplished after penetration by means of a time fuse. It will burn, but without explosion.

## NITROBENZENE.

**Manufacturing Processes.** This is made from benzol, which may be previously rectified on the premises, if not already sufficiently free from other volatiles. The requisite quantity is put in a large iron retort, provided with an arrangement for stirring and for keeping a temperature control on the contents, either by steam or by the circulation of cold water through pipes which may be located within the retort. The mixed acid necessary for the nitration, consisting of nitric and sulfuric acids, is poured slowly into the benzol. At the commencement of the reaction a large amount of heat is generated, which must be carefully controlled, and the liquid is cooled by a current of cold water passing through the apparatus. Toward the end of the process the liquid is allowed to reach about 212° F. It is best to have a recording temperature gauge attached to the apparatus. There must be a reflux condenser to catch the unnitrated benzol and the volatile oil of mirbane which might otherwise escape. These are inflammable and explosive vapors. The product is distilled from the apparatus, or carried off by steam, or "washed" in another tank, and separated by gravity from water and acids.

The chemical reaction is as follows:




**Hazards.** An explosion occurred on the 26th of February, 1915, in a nitrobenzene factory at Rummelsberg, Germany. Without starting the stirrer or the cooling water, a workman ran the nitrating acids into the benzene, the charge forming two layers. When the stirring gear was thrown in, heat was suddenly evolved, the cover of the apparatus was blown off, and the escaping nitrobenzene and benzene vapor formed with the air a mixture which exploded, either spontaneously or was fired by sparks from fragments of the iron vessel, or possibly by nitric acid coming in contact with hemp and straw packing. The use of interlocking cocks was adopted after a somewhat similar accident at another works.

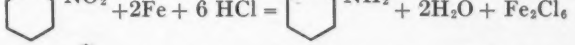
As any vapor escaping from the nitrating apparatus will be inflammable and explosive, all open lights must be excluded from the building. All electric wiring should be conduit and with double enclosed vapor-proof globes, and outside switch boxes.

**Properties.** Nitrobenzene, mononitrobenzene, or oil of mirbane, $C_6H_5 \cdot NO_2$, is generally a light yellow liquid, but when pure is a colorless, highly refractive liquid having a boiling point of about 505° F., which on cooling crystallizes in long needles with a melting point of about 45° F. It is slightly soluble in water, and is miscible in all proportions with organic solvents. It is also volatile in steam. Flash point is 194° F.

Its principle use is for the manufacture of aniline oil, and its manufacture will be found as the first and most hazardous step in the manufacture of the latter. Its presence may be always quickly detected by the characteristic odor of bitter almonds. Owing to this property it is used as a substitute for the oil of bitter almonds for flavoring and perfumery purposes under the name of "oil of mirbane." It is frequently used in stains, etc., found in shoe shops.

## ANILINE.

**Manufacturing Processes.** This product is generally known in the trade as aniline oil. It is produced by reducing nitrobenzene with iron in the form of filings, borings, etc. The vessels used are made of boiler plate, and are about six feet in height and several feet in diameter. An opening at the bottom allows the vessel to be emptied. An important adjunct is the stirrer. The axis of the stirrer may be hollow through which steam may be introduced. Definite proportions of water, iron and hydrochloric acid are first put in the apparatus, then the requisite amount of nitrobenzene added with constant stirring. Steam is then passed in, and more iron added in small amounts, to accelerate the action. The process lasts for eight hours and is so arranged that the vapors which escape are cooled by a reflux condenser. When the process is finished the acid is neutralized with lime, and the aniline produced separated by steam distillation. The vapors are cooled in a worm condenser, when the liquid obtained forms two layers which may be separated. One layer is aniline, the other is water containing about 2 or 3 per cent of dissolved aniline. This water is used for producing the steam necessary for the next operation, thus recovering the aniline which it contains in solution. The aniline is purified by distillation The chemical reaction is as follows:




**Hazards.** The principal hazard is in the use of the finely divided iron such as the turnings etc. used, which are subject to spontaneous ignition when in piles and exposed to moisture. There is also the hazard incident to the presence of an inflammable and volatile liquid.

**Properties.** Aniline, amido benzene, or phenylamine, $C_6H_5 \cdot NH_2$, is a colorless oil, boiling at about 362° F. It is heavier than water and is soluble to the extent of 3 per cent. It is readily soluble in alcohol and ether. On exposure to air, aniline becomes a brownish yellow, becoming ultimately almost black. It has a faint characteristic odor. Pure aniline or its hydro-chloride "aniline salt," is used in dyeing for producing aniline black. The hydro-chloride forms white crystals, with melting point of about 378° F. which becomes greenish black on exposure to air. Aniline oil is finding wide application as a compounding and enlivening material in the rubber mills. It forms a series of well crystallized salts, important in the color industry. Aniline is combustible and volatile and a sufficient quantity of its vapor is inflammable. It has a flashpoint of about 168° F.

## SYNTHETIC COLOR WORKS (Aniline Dye Industry).

A synthetic color works may contain some, or all of the numerous fundamental processes previously described, together with the processes of a synthetic benzol plant, and benzol nitration plant together with other processes which are distinctive to this class.

## ECONOMIC CONSIDERATIONS.

There is no doubt that as soon as it will be found profitable to manufacture all kinds of synthetic dyes here in the United States, instead of a few as at present, there will be little further delay in supplying the demand. We now have developed the great sources of raw materials in the business of recovering coal tar residuals, as previously described. Many of the plants now confining their output to war chemicals, will be admirably adapted for this new industry. Furthermore, tariff regulation, favorable to this industry is predicted. With these conditions in mind, and in view of the abnormal conditions now existing, it is quite possible that this branch of manufacturing may be stimulated to the point of over-production with the important moral hazard, to be taken into account. In this connection it becomes pertinent to consider a few economic features of this business.

The following is the estimated distribution of total production of the coal tar dyes for 1912.

| | |
|---|---|
| Germany | $68,222,846 |
| Great Britain | 5,982,675 |
| Switzerland | 6,452,651 |
| France | 5,000,000 |
| United States | 3,750,000 |

Russia, Holland and Belgium must be added. Allowing $10,000,000 for these, which is clearly very high, makes the absolute maximum production of the world nearly $100,000,000. The combined actual factory area, or works area of the world coal tar dye plants has been estimated

not to exceed over one square mile. Furthermore, and of greater importance to us, the annual importation of dyes and synthetic products from Germany into this country, amounts only to about $9,000,000, which represents approximately the same sum of money, as that which is annually received by the Woolworth Ten Cent Stores for the sale of candy alone.

There were 921 distinct dyes on the market in 1912, divided into 17 separate chemical classes and these into innumerable combinations. The entire industry is a maze of interlocking products and by-products, great in number but, in most cases, small in volume individually. In 1897 the total number of different brands or commercial varieties of dyes sold by a single German concern all over the world amounted in round numbers to 8,000. Each one of these 8,000 has its peculiar advantage over each of the others. This necessitates the production of sample cards by the dye makers each season to show how the fashionable shades and staple shades can be made. Innumerable combinations for producing certain colors and delicate shades are also covered by patents.

It is very apparent, therefore, that the aniline dye industry cannot grow to any enormous proportions. If many plants take up this work, it will behoove Underwriters to look well into the financial security and moral hazard.

## RAW MATERIALS.

The principle raw materials used in the aniline dye industry are the 9 coal tar residuals previously mentioned. Out of the 155 distinct chemical substances in tar, amounting to 6 per cent of the weight of coal, the coal tar dye industry uses only these 9, which make up about 6 to 12% of the tar, or from 0.38 to 0.75% of the coal. With comparatively few exceptions these raw materials cannot be directly converted into dyestuffs. It is first necessary to convert these 9 so-called crudes into intermediate products of which there are about 300, which differ in properties from the raw materials due to the introduction of new groups. From these intermediates which are not dyes, 900 or more dyes are produced. The 921 dyes on the market in 1912 may be divided into 17 separate chemical classes.

## FUNDAMENTAL PROCESSES OF MANUFACTURE.

The intermediate substances are obtained by the six principal types of reactions previously described under Fundamental Processes Consisting of Sulfonation, Alkaline fusion, Nitration, Chlorination, Reduction and Alkylation. There are five other types of operations which are used either individually, serially or in various combinations, in the production of certain intermediates or complete colors. These processes are the following:

**Oxidation.** This is effected largely by means of lead peroxide, manganese dioxide and permanganates. Hydrochloric or sulfuric acids are

used although the former to the greatest extent. Potassium bichromate and chlorate of potash are also used for oxidation purposes. An important intermediate product called anthraquinone results from the oxidation of anthracene.

**Liming.** This is generally applied to sulfonation products in order to separate the different chemical substances from each other. As a general rule the lime salt of one or more is soluble and of the other unsoluble. Lime or chalk may be used, but generally lime is preferred on account of absence of frothing, but where that is not objectionable limestone or chalk is used. In another phase of liming, however, caustic lime is necessary, as in separating benzal chloride from benzo-trichloride; the former gives benzaldehyde which is blown off by steam and the latter gives benzoate of lime, which is further decomposed to give benzoic acid.

**Condensing.** This covers all those processes where two different substances (or two molecules of the same substance) unite to form a new compound by the loss or elimination of water or its equivalent between them. Among the most common equivalent of water loss is loss of hydrochloric acid or ammonia. Sulfuric acid is a common condensing agent for this purpose and is used in considerable excess. Chlorides of phosphorus and of sulfur, zinc chloride, aluminum chloride, antimony chloride and the like, may be used. Many distinct dyestuffs are completed or made effective by this method.

**Carboxylating.** This is generally performed by the action of an excess of caustic soda and pure carbon dioxide gas upon a hydroxylated substance such as phenol. For example, phenol or carbolic acid, yields salicylic acid, which is a substance of great importance and has wide application in the coal tar dyestuff art.

**Diazotizing and Coupling.** An amido compound such as alpha-naphthylamine on treatment with nitrous acid yields a compound called diazonaphthalene. This operation is called diazotizing.

When the result is brought into contact with salicylic acid in the presence of sodium carbonate or acetate it yields a new substance. This operation is called coupling. This product on reduction yields a new compound, amido-salicylic acid and the original alpha-naphthylamine. This new compound is also very useful in the production of a line of colors.

To quote Dr. Bernard C. Hesse, "These two operations are the most ubiquitous and widely applied reactions in the entire industry. They serve to help in making intermediate products and to produce the multitudes of substances known as azo dyes which make up more than 50 per cent of the individual dyes of the world's market. This group of azo dyes is a terrific and bewildering maze of interlocked and interlaced substances and operations." Compared with which the making of the 24 dyes later briefly described, "are the merest alphabet of simplicity."

## TYPICAL ANILINE COLOR PRODUCTION.

Having considered broadly, the fundamental operations to be found in a coal tar synthetical chemical or color works, it is of interest, in order to get a practical example of the complexities of the aniline color industry as a whole, with the numerous materials and involved procedures, to consider in detail the manufacture of one line of 24 dyes from a single starting point, a product called "Michler's Ketone." This will be sufficient to show the futility of the average underwriter or inspector trying to concern himself with much beyond a simple enumeration of the chemicals involved and a description of the fundamental processes that may be found. The methods of manufacture of the synthetic products now found on the market, will be found under their respective headings.

Michler's Ketone is prepared from dimethyl aniline and carbonyl chloride. Dimethyl aniline is made from aniline, aniline salt and acetone free wood alcohol; aniline itself from nitrobenzol and that from benzol and nitric acid. Carbonyl chloride is made from equal volumes of carbon monoxide and chlorine by means of a contact agent, preferably animal charcoal. Platinum has also been used. It is made chiefly by a process patented by Michalske. In this process calcium chloride is heated with lime and coke breeze in an electric furnace; the carbonyl chloride is condensed as a liquid at 46° F.

The final ketone is made by passing the carbonyl chloride gas into the liquid dimethyl aniline at ordinary temperature until the weight increases 40 per cent; the mixture is then heated to 212° F. for several hours to complete the reaction. The product is a solid melting at 347° F. To be more exact, this is brought about by four operations, nitrating, reducing, alkylating and condensing, and 12 materials are needed: Benzol, nitrobenzol, aniline, wood alcohol, carbon monoxide, chlorine, phosphorus, nitric acid, sulfuric acid, iron filings, muriatic acid, and animal charcoal. The product of these operations is not a dyestuff; in fact, a dye cannot be made until 18 additional compounds are made.

In general, dyes are made from ketones by treating a mixture of it with phosphorus oxychloride or phosphorous bichloride, with another coal tar derivative, by the operation technically known as condensing.

The manufacture from ketone of these 24 dyestuffs calls for the eleven typical chemical operations, which have just been briefly described. For 12 of these dyes one member of the four classes of organic materials, phenol, benzol, toluol and naphthalene is sufficient; for the other twelve, various combinations of two or three of these organic materials are necessary. The total number of operations involved is 118. Not only are there a large number of operations but these operations, while not always under accurate control, must generally be carried out with great refinement and exactitude.

To carry out these 118 operations the different sets of apparatus are 11 or a multiple thereof, the multiple depending on the relative quantities

of the dyes to be made and the time at which they must be manufactured, and further, one apparatus is not necessarily adapted for operation on different compounds.

It must be borne in mind that this description does not attempt to show the manufacturing operations and steps necessary to accomplish the indicated results; nor the filtering operations, the precipitations, the blowings off with steam and other means of mechanical separation. Between each two successive chemical alterations, there are one or more mechanical operations, not indicated, as well as secondary chemical changes such as the conversion of sulfo-acids into salts; bases into salts; the separation of the salts from their liquids and their purification, drying and storing. In addition to all this, there is the large amount of testing that must be done at all stages of each operation, and exhaustive and careful tests of each lot of product before it is passed from one step to the other, and of the finished dye before it is placed in the warehouse.

## HAZARDS.

The synthetic color works are fraught with a multitude of hazards. A large quantity of inflammable and explosive volatiles are bound to be present. Sulfonation and nitration of benzol and its homologues offer hazards which have been previously described. Certain dye products are themselves explosive under certain conditions, such as picric acid, and many of them, especially the nitration products, are readily inflammable. Many of the so-called "intermediates" will be hazardous from which, resulting colors may be made that are quite inert. If the products are dried and ground other hazards are introduced which can be readily appreciated.

The greatest precautions should be taken to ensure free and perfect ventilation, and to have storage of both raw materials and finished goods carefully segregated. No open lights of any kind should be allowed. Electric equipment should be installed in conduit with double globe, vapor-proof lamps and outside switches. Smoking must be strictly prohibited.

# PART IV.

## COMPARATIVE HAZARDS OF THE ULTIMATE PRODUCTS PREVIOUSLY DESCRIBED.

Brisant Explosives are those which can be exploded only by means of a detonator, and not by flame alone. "Brisance" is practically equivalent to the term "disruptive effect" and depends mainly on concentration of energy in unit volume. The explosives under discussion are all considered of this brisant type. The following opinions from authoritative sources are offered, from which, one may get some idea of the comparative hazards, as well as the conflicting opinions held.

**Trinitrotoluol.** In the Thirty Fifth Annual Report of H. M. Inspectors of Explosives, Home Office, London, 1911, it is noted that an event of special interest was the issuance of an order in Council exempting T. N. T. from being deemed an explosive during manufacture and storage unconditionally and when conveyed or imported provided it is properly packed and this was done after application had been made to fill shells with this substance as the sole bursting charge.

Von E. Molinari and F. Quartieri, have the following to say in the November, 1913, issue of Zeitschrift für das gesamte Schiess-und Sprengstoffwesen. "Theory and experience have taught that all explosives explode or can explode when in contact with fire. The underlying principle appears to be almost a paradox, and yet, it has been shown in the case of T. N. T. that there is no danger. In mentioning the physical properties of T. N. T. it has been shown that it may be heated way over its melting point and that it burns with rapid combustion at 468° F., but only seldom detonates. If it is heated in a platinum dish, with a small flame, it first melts, then vaporizes or sublimes, for the most part unchanged. Upon stronger and quicker heating it ignites and then burns with a separation of carbon and smoke, still without exploding."

In 1909, there was a fire in the German Explosive factory of Allendorf Schoenebeck on the Elbe, in the room in which T. N. T. was crystallized from alcohol, the flames attacked the entire room in which there was a large amount of a liquid mixture of T. N. T. and nitro-cellulose. The mixture burned without exploding. On the 27th of June, 1912, there was in the same factory a fearful explosion followed by a fire and a large loss. In the weighing room tons of practically undecomposed T. N. T. was found, while in another room the T. N. T. was burned on the surface, but an explosion did not take place here.

M. Verola, in Memorial des poudres et Saltpetres, 16: 40-51, describes experiments to determine the vapor tension and stability of T. N. T. at high temperatures by means of special apparatus. The volumes of gas liberated from a definite quantity of T. N. T. at increasing tempera-

tures were measured during definite intervals of time. It was noted that there was a gradual decomposition of the substance at temperatures much below its point of deflagration in air.

From an original melting point of 177° F., heating 5 hours at 356° F. reduced the melting point to 172.4° F., 2½ hours at 393° F. gave a melting point of 170.6° F., one-half hour at 405.5° F., a melting point of 138.2° F. Continuous heating at 266° F. for 100 hours had no effect on the melting point, while 80 hours on the same sample at 356° F., reduced the melting point to 176.45° F. and 177 hours at 302° F. gave a further reduction to 175.8° F. It is evident that the explosive is very stable at 266° F., decomposition beginning at about 302° F. and increasing rapidly as the temperature rises.

From these results T. N. T. shows a marked similarity to nitrocellulose in its behavior, although only affected by much higher temperatures than the latter. Saposhnikov found that nitro-cellulose (12.0% Nitrogen) evolved gases at 248° F. which corresponded with the rate of decomposition of T. N. T. at about 356° F. He concludes with the statement that T. N. T. is evidently a perfectly stable explosive at ordinary temperatures.

**Picric Acid.** In regard to Picric Acid, Thomas Osborne, writing in the chemical Engineer, reprinted in the October, 1915, Quarterly of the National Fire Protection Association (Vol. 9, No. 2, Page 136) has this to say: "Experience and records suggest that it should be impossible that an explosion of unconfined picric acid should occur, provided that the quantity in any one building is limited to a moderate amount and that no picrates are present. Under ordinary conditions the risk is one rather of fire than of explosion, consequently the buildings are not usually placed very far apart; as they undoubtedly would be if explosion were an ordinary risk. In the case of one explosion the whole quantity of loose picric acid appears to have detonated without warning and to have communicated sympathetically to other buildings in which unprotected acid was present. The hitherto accepted theory that picric acid cannot be exploded by friction or heat, unless confined, is open to doubt."

He then discusses the hazards that prevail where picric acid is fabricated into the finished explosive, processes which deal with a dry product, which is not found in the manufacture of the raw material.

He further states: "Apart from ignition there is explosion to be considered, which occasionally immediately follows. * * * In the case of one disastrous explosion it was established beyond the possibility of doubt, that it was due not to picric acid alone, but to the presence of considerable quantities of lead and strontium compounds, which under the influence of heat and in contact with the melted picric acid led to the formation of lead and strontium picrates, both of which and more particularly the lead salt, are not only in themselves violently explosive, but are capable of detonating picric acid in contact with them.. It is noteworthy that it is stated in books on the subject by chemists of the highest standing, that

when sudddnly heated, picric acid will explode; it is not possible to obtain confirmation of the statement in the actual experience of manufacturers, or from the accounts of accidents which have taken place, or from experiments instituted for the special purpose of clearing up the point. In fact so far as experience, records and experiments go, they may all be said to furnish a very emphatic contradiction of the statements, that picric acid when unconfined can be exploded by fire. A case is recorded in which an iron vessel with a very small orifice and containing 25 lbs. of picric acid was placed in a reverberatory furnace, when the acid burned away without explosion.

On the other hand, it has been found quite possible to explode picric acid by a blow, but this blow must be of considerable force if the material is cold and of a character that could seldom occur in practice. All experience, in fact, seems to prove as surely as negative evidence can be said to prove anything, that it may be taken as a practical impossibility for picric acid to explode without giving sufficient warning by fire to enable anyone in the vicinity to escape, and that, moreover, a fire in its initial stages can be extinguished by water without much difficulty.

In Great Britain, as the result of explosions due to causes which have never been ascertained, picric acid is regarded as an explosive and a license has to be obtained for its manufacture, but conditions of a drastic nature are not imposed and no limit was plåced on the quantity that may be present in a building. Some years ago a serious explosion occured in the north of England at picric acid works. It was suggested by experts after careful inquiry, that it occured after a fire had been raging for nearly ten minutes and that it was probably due to the formation of picrates of lime from the mortar in the roof of one of the buildings that fell in; moreover, that it could not be stated with certainty that it was not caused by the pieric acid alone, which was present in greater quantity than in any instance quoted to establish the contrary view. More recently the quantity has been limited, that may be present in any one compartment; 2,000 lbs. is now considered the maximum which may be allowed in one risk. It is also considered desirable to have sprinklers fitted to every compartment or building likely to contain dry picric acid, as the danger of fire developing into explosion is considered so slight as to be negligible."

A picric acid works explosion in England occured in December, 1914, and a resumé of the proceedings at the inquest held thereafter, is of considerable interest. It was devoted mainly to evidence submitted by Major Cooper-Key, His Majesty's Chief Inspector of Explosives. Although the accident occured in the grinding room, he did not think it was dangerous to grind dry picric acid. It was done in several factories. Personally, he thought it better to grind wet. So far as ignition was concerned, it was easy to put the fire out. In every case of explosion hitherto inquired into, the explosion had been preceded by a considerable fire which had gone on for some time.

In the inquiry at Cornbrook, after another explosion, some of the greatest scientists in the country were asked to carry out experiments in

regard to the dangers of picric acid, and their conclusions were that picric acid could not be exploded merely by heat, but it would simply catch fire and burn. A spark or friction would merely start it burning, and in order to get an explosion, there must be present something as a primer, such as sulfate of mercury or picrite of lead, or there must be strong confinement.

From what Major Cooper-Key had been told about the grinding and sifting buildings, he was confident that the room was full of dust, and he had come to the conclusion that this was not an explosion of picric acid at all, but an explosion of dust (carbonaceous dust) such as could have taken place in a flour mill, or with starch, malt dust, coal dust, etc. Of this he was perfectly convinced. He stated that if steps could be taken to avoid the presence of dust, then they would be getting back to the same conditions which had always obtained, and had always been considered normal, that if picric acid in moderate quantities ignited it would simply burn. He considered that the cause was merely a spark which would start at once the fire in the grinding room, the atmosphere of which was filled with dust. The picric acid in the packing room and magazine did not explode. There was no dust there.

In a fire at Stamford, Connecticut, in November, 1915, the following facts were noted: "The lead lined phenol sulfonating vats were charred and burned and the lead melted down to the level of the liquor. At this point, it was very evident the liquor retarded the further progress of the fire, for the remainder of the vats were intact and the liquor remained therein. It was afterwards removed and put into process in the nitrating building. The large crystalizing tubs containing the dissolved picric acid were in no instance destroyed. The tops were charred and the seams sometimes opened above the level of the liquor. In several places, the yellow salt of picric acid was evident on the outside of the vats where it had leaked through and the liquor evaporated, leaving an unburned yellow stain amid charred surroundings. On the upper levels where the crude acid was located, several boxes and tubs containing this salt, with only 5% of moisture, were partially consumed, the charred remains being visible and in some cases, a considerable quantity of unconsumed acid remained. There were examples to show the action of phenold (carbolic acid) in the fire. One iron drum and several milk cans containing phenol were in the building. This material will burn with a heavy smoke, but not apparently with great vigor, for several cans were upset, with the phenol, which had liquified under heat, resolidified on the side, considerable still remaining in the cans. It is reported that there was not the least sign of an explosion and that the fire was not particularly vigorous."

**T. N. T. and Picric Acid.** Dr. M. Neuman states in the November, 1911, issue of the Zeitschrift für angewandte Chemie und Zentralblatt für technische Chemie, that T. N. T. and Picric Acid are by themselves harmless and that it is well known that picric acid has been used for a long time in textile work. He goes on to say that on the other hand a small capsule of less than one gram of fulminate of mercury suffices,

by detonation, to bring picric acid under great energy strain. What makes this action so fearful is above all, its extraordinary high denotation velocity of some 7,000 to 8,000 meters per second. He states that the brisance of nitro-glycerine is 2,000 meters per second, and mentions that the products of combustion contain over 50 per cent carbon monoxide. Picric Acid has been used for the past two decades in armies. It is generally used in fused or pressed form, and has shown good results.

T. N. T., he states, is stable and does not form, like picric acid, dangerous salts. It is not as easily detonated as picric acid, and not so strong Its detonation velocity is a little less than that for picric acid.

**Wet Gun Cotton and T. N. T.** F. Von Schroetter, in the Zeitschrift für das gesamte schiess-und Sprengstoffwesen gives some experiments that show the superiority, or greater sensitiveness to detonation influences of T. N. T. over wetgun cotton, when used as a charge for mines or torpedoes. Two kilogram charges of the explosives were compressed in strong hollow metallic shells. 2 to 3 M. M. in thickness, these charges being placed at definite distances from a similar charge of a brisant explosive acting as a primary charge. The maximum distance at which explosion of the secondary charges resulted on detonation of the primary charge was determined. T. N. T. detonated in every case in 10 trials at 110 C. M., while the wet gun cotton detonated in only four trials out of 10 at 80 C. M. Unconfined compressed charges of T. N. T. detonated at a distance of 7.5 C. M. from the primary charge, while the wet gun cotton required a distance of only 3 C. M.

This would seem to show that unconfined wet gun cotton was fairly susceptible to detonation influence and is more unstable than T. N. T. It is considered by some chemists to be on a par with picric acid.

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# Department of Fire Record.

## Printing and Lithographic Establishments — Fire Record.

The record given in this issue of the QUARTERLY is made up of reports on fires in printing, lithographing and binding establishments which have occurred during the years 1907 to 1915. A similar fire record was published in the QUARTERLY bulletin of January, 1907, and offers an excellent opportunity for comparison.

A study of the fire record of any class of occupancy naturally begins with an investigation of the causes. Such an investigation in this instance cannot help but impress one with the fact that two causes are responsible for a very great proportion of the fires in these plants. Smoking represents 13.7 per cent of all the known causes and oily rags or waste 21.9 per cent. Reference to the old record shows that the item of smoking was then only 5.1 per cent. This very large increase is certainly interesting and may possibly be explained by the increasing use of cigarettes. These are so small that they may be easily concealed while being smoked and, if necessary, can be quickly tossed aside — hence the large number of fires from this cause. They particularly appeal to newsboys, etc. A practical remedy for this increasing hazard is not easily found. Oily rags and waste is the principal special hazard and may be largely controlled by good housekeeping methods and the use of standard waste cans. These cans should be emptied at the end of each day. There has been a slight decrease in this hazard, since the old record shows 27.8 per cent of the fires originated from this cause. The items of boiler or fuel, power and matches seem to be disproportionately large.

The number of large loss fires in all plants of this kind is very high, representing as it does more than one-fourth of all the fires. This is in part explained by the large number of country printing plants which are located in old neglected frame buildings and the susceptibility of the contents to damage by water or fire.

The time of day at which fires occurred indicates that an appreciable majority take place at night and when the plant is not in operation. This is quite to be expected when one considers that so many of the fires result from spontaneous ignition or smolder for a time before breaking out. The large number of fires, sixteen per cent, discovered by the sprinkler alarm is a point to be noted as well as the high value of thirty-eight per cent credited to the watchman.

The data on the efficiency of sprinklers in this class of occupancy particularly emphasizes the value of such a system in these plants. The fact that 89.5 per cent of the fires were extinguished by three heads or less is an enviable record for sprinkler protection. In plants equipped with sprinklers there were only 5.9 per cent large loss fires; without such protection the percentage of large loss fires was very much greater. The average number of heads opening, 2.63, is a very low value and indicates how readily sprinklers can control the situation. It is suggested that readers compare the data on the efficiency of the automatic sprinklers with the tables given in the October, 1915, Quarterly which embrace various classes of occupancy.

In conclusion it seems desirable to again call attention to the fact that oily rags or waste and smoking are the two primary causes of fires in printing and lithographing properties. The automatic sprinkler is unusually efficient in this class of occupancy since so many of the fires occur at night from spontaneous ignition or after smoldering for hours. A single sprinkler head often extinguishes a fire quickly and at the same time, if the system is equipped with an alarm, gives notice of its discovery.

# Printers and Lithographers — Fire Record.

TOTAL NUMBER OF FIRES REPORTED, 480.*

## 1. CLASSIFICATION OF CAUSES.

### Summary.

### Common Causes.

| | No. of Fires. | Per Cent of Common Causes. | Per Cent of Known Causes. |
|---|---|---|---|
| Heating | 19 | 10.0 | 5.5 |
| Lighting | 21 | 11.1 | 6.0 |
| Electrical defects, 15. | | | |
| Power | 28 | 14.8 | 8.0 |
| Electrical causes, 21. | | | |
| Lightning | 3 | 1.6 | .9 |
| Smoking | 48 | 25.4 | 13.7 |
| Independence Day | 1 | .5 | .3 |
| Chimneys and Flues | 5 | 2.7 | 1.4 |
| Matches | 16 | 8.5 | 4.7 |
| Boiler (or fuel) | 28 | 14.8 | 8.0 |
| Rubbish (or sweepings) | 11 | 5.8 | 3.2 |
| Miscellaneous | 9 | 4.8 | 2.6 |
| Total | 189 | 100.0 | |

*Includes data from Fire Patrol Reports which was not sufficiently complete to use in all the tables.

## Special Hazard Causes.

| | No. of Fires. | Per Cent of Special Hazards. | Per Cent of Known Causes. |
|---|---|---|---|
| Oily Rags or Waste | 76 | 54.3 | 21.9 |
| Paper Cuttings and Waste Paper | 16 | 11.4 | 4.7 |
| Benzine | 14 | 10.0 | 4.0 |
| Linotype or Monotype Machine | 2 | 1.4 | .6 |
| Stereotype or Electrotype | 13 | 9.3 | 3.7 |
| Photo-engraving | 7 | 5.0 | 2.0 |
| Glue Pots | 1 | .7 | .3 |
| Printing Press | 5 | 3.6 | 1.4 |
| Printers' Inks | 1 | .7 | .3 |
| Miscellaneous | 5 | 3.6 | 1.4 |
| Total | 140 | 100.0 | |
| Common Causes | 189 | | 54.3 |
| Special Hazard Causes | 140 | | 40.3 |
| Incendiary | 12 | | 3.4 |
| Exposure | 7 | | 2.0 |
| Total Known Causes | 348 | | 100.0 |
| Unknown Causes | 132 | | |
| Total | 480 | | |

# Details of Causes.

Under this heading are given brief descriptions of fires caused by unusual conditions, or which are of an educational value in emphasizing the different hazards. Fires caused by ordinary conditions or well understood hazards may not be included.

## COMMON CAUSES.

### Heating.

**S-12036.** Gas stove was left burning all night. It set fire to the floor, which was discovered smoldering in the morning.

**H-8221.** Some wooden shelves on which had been piled various kinds of printed matter, were placed over a steam radiator. Fire evidently started on or under the first shelf nearest the radiator and ran up the wall side of the paper on the shelves.

### Smoking.

**H-9903.** This fire occurred among a lot of waste paper at the bottom of elevator shaft and was apparently caused by a cigarette stump which had been thrown down the shaft.

**S-17833.** A small amount of sawdust was kept on the floor under the engine to absorb the oil. Fire might have been caused by spontaneous ignition of this oil-soaked sawdust but engineer was inclined to believe that it was started by a lighted match or cigarette thrown down the elevator shaft by someone.

### Electrical.

**S-11703.** An employee was tampering with a light when he caused a short circuit, the arc of which ignited some paper dust.

**S-17275.** A small 500-volt motor under bench was supplied by current through wire in conduit passing through floor near the motor. The wire becoming short circuited split the conduit, setting fire to the floor and wooden wainscoting of the room.

**S-17914.** This press which was operated by a girl was controlled by a starting box within easy reach of the operator. It was left with the starting handle on the third notch when the plant closed for the noon hour. Shortly after noon the current was turned on. Starting box overheated and caused fire.

**S-11615.** Water from a leaking radiator ran down into a cut-out box and caused a short circuit.

### Power.

**S-13818.** Cause was apparently due to friction from belt running on loose pulley to paper cutter. Paper clippings underneath became ignited. Fire was extinguished by one sprinkler head.

### Lighting.

**S-16625.** A mechanic working on a machine used a candle for light, which upset and ignited loose paper on the floor nearby.

### Boiler (or Fuel).

**H-9854.** This fire occurred in a small portion of the basement used for the storage of coke, which was partitioned off from the boiler room by a two-inch frame tin-clad partition. A pile of coke had been stored in this bin for a long time, and the cause of the fire is attributed to spontaneous combustion.

## SPECIAL HAZARD CAUSES.

### Oily Rags or Waste.

**H-6827.** Clean rags were kept in wooden boxes but apparently some dirty rags were carelessly dropped into one of these boxes. They ignited spontaneously but fire was promptly extinguished by a single sprinkler head which was located near the box.

**S-8653.** Fire was apparently caused by a pair of oily overalls igniting from spontaneous combustion. These overalls were hanging in a clothes closet which had the wooden top removed and a piece of cloth substituted. This cloth burned away allowing the heat to open one sprinkler which extinguished the fire.

**S-16881.** Fire ocurred about 11 P. M. in a barrel of oily rags, sweepings, etc., which had been left standing in front of electric fuse cabinet, the door of which was open. It was thought that an open link fuse blew out throwing a spark which ignited this rubbish.

**S-15114.** Fire started in a truck load of varnished sheets of labels which were packed tightly against a large case of paper. The inks used in these labels were mixed with linseed varnish and it is supposed that the stock heated spontaneously.

**S-17678.** Fire occurred among rags formerly containing benzine, which had been washed with water and then hung up to dry on a line strung over a low pressure boiler. Three of the rags fell on top of boiler and became ignited. Fire was extinguished by three sprinkler heads.

**S-15535.** This fire probably started from spontaneous combustion of oily waste in engineer's supply locker over desk in boiler room.

## Presses.

**S-18091.** Fire occurred on a cylinder press equipped with a perforated gas pipe for flame used in drying each sheet as printed. It was thought that one of the printed sheets as it passed over the drying frame ignited and, in turn, ignited a pile of paper upon which it was automatically placed. Two sprinkler heads extinguished the fire, but there was a loss of $1,000.

**S-17877.** Fire resulted from the ignition of a sheet of paper becoming obstructed above the gas flame which was used on the presses for drying the sheets and the demagnetization of the paper. Fire is of rather common occurrence at this point but the attendant usually catches the sheet, crumpling it up before any damage takes place. In this instance however the paper was probably laid on the truck before the attendant noticed it was on fire. There was a loss of about $200.00.

**S-16130.** Press was used to print the illustrated supplement of a newspaper, and as a clean and perfect print was required it was usual to dry the paper over a series of open gas flames. These flames issue from small perforations, about one inch apart, in a one-inch pipe connected by a rubber tube to an overhead bracket. While the press was in operation the paper stuck on the conveyor and immediately caught fire, the flames being communicated to the other sheets which followed. Employees stopped the machine and put out the blaze with a few pails of water before it had gained sufficient proportions to open the sprinklers.

**S-17633.** A sheet of printed paper when being delivered from the large press became "jammed" long enough so that it was ignited by the gas flame which was used to counteract the static electricity in the sheets. The operator removed the burning sheet and threw it on the floor. However, it accidentally dropped near a pile of valuable finished stock, the edges of which took fire. Two or three pails of water immediately extinguished the blaze. About 4,000 sheets of the finished catalogue stock were ruined by fire and water, causing a loss of $533.72.

It is quite a usual occurrence for paper to catch fire in this manner so that extreme care should be taken not to have any valuable finished stock in the vicinity.

## Furnaces.

**S-18126.** A coal heated melting pot for the stereotype furnace was located on an eight-inch concrete slab above the wood floor built up as follows: One inch wood floor resting on joists, three-ply asbestos, two-inch concrete, three layers of expanded steel (for air space) and six inches of concrete. One morning smoke was noticed coming through the floor, and investigation showed that the joists had become charred and were about to burst into flame. Prompt discovery prevented any serious damage.

**S-16623.** The woodwork around ventilating fan over stereotype kettle became ignited by sparks from the kettle. Fire was extinguished by one sprinkler.

**S-11185.** A large coal heated melting pot was located on the top floor with asbestos insulation beneath it. The floor was further protected by metal but the heat from the pot gradually charred the floor and joists underneath until the ceiling and the floor below were ignited. Prompt discovery prevented the fire from making any headway.

**H-6350.** A gas heated type-metal pot was located on a cement floor about three and one-half inches thick, into which top edges of joists extended approximately one and three-quarters inches, thus leaving about one and three-quarters inches net thickness of concrete over these joists. The heat had gradually charred the wood until finally it broke into flame.

### Volatiles.

**S-11183.** Benzine which was used for cleaning the ink rolls of a lithographing machine dripped into a starting-box. As one of the cleaners started the press to change the position of the rolls, a spark in the starting box ignited this benzine and the fire spread quickly. It was extinguished with sand and chemical extinguishers.

**S-16523.** An employee in the printing and lithographing department was heating some asphaltum and turpentine in an iron kettle on a gas stove. He raised the cover of the kettle to see if the mixture was ready for use when the contents suddenly burst into flame. Two sprinkler heads extinguished the fire.

**S-14207.** While employee was cleaning some small parts of machinery with benzine another employee passed near him with a lighted torch which ignited the vapor from the benzine. One sprinkler head opened and extinguished the fire.

**H-1786.** An employee was preparing collodion from ether and soluble gun cotton, shaking the contents in a glass bottle which had the stopper removed. He was about six feet from a small gas stove which was lighted at the time. He admitted that some of the contents of the bottle was spilled and the vapor from this evidently was ignited by the flame.

**S-17056.** A kerosene stove was filled with gasoline by mistake. When the stove was lighted it flared up and the blaze spread to a table on which was printed matter. Fire was extinguished by one sprinkler before it made great headway.

### Miscellaneous.

**S-15402.** Fire was caused by gas accidentally left burning in a small wooden enclosure used for boiling water out of nitrate of silver solution. One sprinkler opened and confined the fire to this enclosure.

**S-15457.** Fire started among a few small wooden trays containing printers' dry colors (blue bronze). These trays were placed directly over the steam pipes in a metal lined dry room in order to dry the colors. Apparently the trays were placed too close to the steam pipes and became ignited by the heat.

## 2. MISCELLANEOUS STATISTICS.

### Analysis of Loss.

| | Common Causes. | | Special Causes. | | Unknown Incendiary Exposure. | | Total. | |
|---|---|---|---|---|---|---|---|---|
| | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. |
| No Claim | 46 | 29 | 23 | 19 | 12 | 8 | *81 | 19 |
| Small Loss | 80 | 50 | 85 | 70 | 61 | 44 | 226 | 54 |
| Large Loss | 33 | 21 | 13 | 11 | 67 | 48 | 113 | 27 |
| Total with data given | 159 | 100 | 121 | 100 | 140 | 100 | 420 | 100 |
| No data | 4 | | 5 | | 10 | | 19 | |
| Total | 163 | | 126 | | 150 | | 439 | |

## 3. DAY OR NIGHT FIRES. (Day Fires 6 a. m. to 6 p. m.)

| | Common Causes. | | Special Causes. | | Unknown Incendiary Exposure. | | Total. | |
|---|---|---|---|---|---|---|---|---|
| | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. |
| Day | 96 | 54 | 60 | 43 | 37 | 26 | 193 | 41 |
| Night | 89 | 46 | 79 | 57 | 107 | 74 | 275 | 59 |
| Total with data given | 185 | 100 | 139 | 100 | 144 | 100 | 468 | 100 |
| No data | 4 | | 1 | | 7 | | 12 | |
| Total | 189 | | 140 | | 151 | | 480 | |

## 4. PLANT IN OPERATION.

| | Common Causes. | | Special Causes. | | Unknown Incendiary Exposure. | | Total. | |
|---|---|---|---|---|---|---|---|---|
| | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. |
| Plant in operation | 84 | 56 | 44 | 36 | 40 | 29 | 168 | 41 |
| Plant not in operation | 67 | 44 | 78 | 64 | 97 | 71 | 242 | 59 |
| Total with data given | 151 | 100 | 122 | 100 | 137 | 100 | 410 | 100 |
| No data | 12 | | 4 | | 13 | | 29 | |
| Total | 163 | | 126 | | 150 | | 439 | |

* Seventy-one of these fires were in buildings equipped with sprinklers.

## 5. HOW DISCOVERED.

| | Common Causes. | | Special Causes. | | Unknown Incendiary Exposure. | | Total. | |
|---|---|---|---|---|---|---|---|---|
| | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. | No. of Fires. | Per Cent. |
| Employee | 82 | 52 | 44 | 35 | 33 | 24 | 159 | 38 |
| Watchman | 16 | 10 | 20 | 16 | 16 | 11 | 52 | 12 |
| Thermostat | 6 | 4 | 7 | 6 | 4 | 3 | 17 | 4 |
| Sprinkler Alarm | 20 | 14 | 29 | 23 | 21 | 15 | 70 | 16 |
| Outsider | 31 | 19 | 15 | 12 | 63 | 45 | 109 | 26 |
| Supervisory | 3 | 1 | 10 | 8 | 3 | 2 | 16 | 4 |
| Total with data given | 158 | 100 | 125 | 100 | 140 | 100 | 423 | 100 |
| No data | 5 | | 1 | | 10 | | 16 | |
| Total | 163 | | 126 | | 150 | | 439 | |

## SPRINKLER FIRE RECORD*

## 6. EFFECT OF SPRINKLERS.

| | No. of Fires | Per Cent of Whole. |
|---|---|---|
| Extinguished or practically extinguished fire | 168 | 82.3 |
| Held fire in check | 31 | 15.3 |
| Unsatisfactory | 5 | 2.4 |
| Total | 204 | |
| No claim | 56 | 27.4 |
| Small loss | 136 | 66.7 |
| Large loss | 12 | 5.9 |
| Total | 204 | |

*There were 42 fires in which the heat was insufficient to open any sprinklers.

## 7. NUMBER OF SPRINKLERS OPENED.

| No. of Sprinklers Operating. | No. of Fires. | Per Cent. | No. of Sprinklers Operating. | No. of Fires. | Per Cent. |
|---|---|---|---|---|---|
| 1. . . . . | 121 | 60.1 | 1. . . . . | 121 | 60.1 |
| 2. . . . . | 40 | 19.9 | 2 or less . . . | 161 | 80.0 |
| 3. . . . . | 19 | 9.5 | 3 or less . . . | 180 | 89.5 |
| 4. . . . . | 7 | 3.5 | 4 or less . . . | 187 | 93.0 |
| 5. . . . . | 1 | .5 | 5 or less . . . | 188 | 93.5 |
| 6 to 9 inc. . . . . | 3 | 1.5 | Less than 10, | 191 | 95.0 |
| 10 to 24 inc. . . . . | 6 | 3.0 | Less than 25, | 197 | 98.0 |
| 25 to 49 inc. . . . . | 1 | .5 | Less than 50, | 198 | 98.5 |
| 50 and over . . . . | 3 | 1.5 | 50 and over, | 3 | 1.5 |
| Total . . . . . | 201 | 100.0 | | | |

Average number of sprinklers opened, not including unsatisfactory, 2.63.

## 8. UNSATISFACTORY OR LARGE LOSS SPRINKLER FIRES.

**S-5612.** This plant consisted of four sections known as the old building, the new building, the new addition, and the storehouse building. The buildings were all of brick and joisted construction. There were two fair cut-off walls between the new and old building and one between the new building and new addition. The openings were protected by good two and one-half inch fire doors of the swing type but which were not automatic. The sprinkler equipment was complete and had for supplies, first, high service waterworks with a pressure of 120 pounds and, second, a 500 gallon steam pump which gave a pressure of about thirty-eight pounds.

A fire was discovered in the plant at about 3.10 A. M. in the basement near stair tower at rear of the building. In this stairway almost directly over where fire started were stored small quantities of benzine, kerosene, etc. The watchman upon discovering the fire called the night fireman and they apparently extinguished it with chemical extinguishers and the aid of two sprinklers which opened. Fireman then shut off the high service valve of the sprinkler system and low service valve of the pump discharge and then opened drips to prevent unnecessary water damage. He then started to telephone to the superintendent. The watchman started on his four o'clock round a little early and had reached the second floor of new building when on looking toward the old building he saw the whole rear portion of it in flame. He then went back to the engine room and told the fireman to send in a telephone call to the fire department. After some difficulty the watchman was able to reach the valve at the pump discharge which supplied low service water to sprinklers and opened this. The fire department responded and upon finding that the fire was making rapid progress sent in a general alarm. Certain unfortunate mishaps to the fire department apparatus prevented their work from being as efficient as usual. Although the opening of the low service valve may have produced

some effect, it is probable that the fire had reached such proportions at that time that the work of the sprinklers was of little use. The loss was a large one.

*Summary*: Water shut off from sprinkler system.

**S-6237.** Fire probably started on the third floor near openings for power transmission and communicated through three small belt openings to all floors above, also down to the second floor. The fire chief in charge of the fire, who was among the first firemen to arrive, maintained that there was no water coming from the sprinklers and that there was no indication of water on the floor when he arrived. The local boiler fireman, who was the only man on the premises at the time the fire started, maintained that the first indication he had of trouble was the operation of a local alarm valve. Upon investigation he saw the fire and he immediately opened the city water connection to automatic pump. It appears to have been the practice of the engineers and others in charge of the equipment to first close the system gate valve if the local bell rang and then make a tour of inspection, and in case of fire to open the valve again. It seems probable that this fireman shut the gate valve and as soon as he saw there was a fire opened the valve, but in the meantime a very large number of heads had opened. The pumping of water into system by the city engines through two single steamer couplings and the water from the pressure tank and pump undoubtedly prevented the complete destruction of the building, as the fire was burning from the second floor to the roof by the time fire department arrived.

**S-5636.** This eight-story and basement building of ordinary construction was equipped with two types of obsolete sprinklers arranged in a pendant position and covering about 110 square feet area each. The only water supply was a gravity tank of 3600 gallons capacity ten feet above highest heads. Fire started in the basement of the building and spread rapidly through ink mixing rooms to elevator shaft and upper floors. Fire doors which were open and were not automatic permitted the heat to pass through, opening thirteen heads in the basement which practically drained the tank. The fire department connected to steamer coupling but did not pump much water into the system. Fortunately their efficient work checked the fire. The sprinklers were of some service in holding the fire in check but the water supply was so poor that the water was soon exhausted.

**S-16997.** Building where fire occurred was of frame construction with concealed spaces in walls and ceilings, the latter having sheet steel secured to the inside of joists. Fire worked its way to the attic and roof behind a wood sheathed partition, and also spread to the concealed spaces under the joisted flat roof and joisted floor of the second story. Sixty-six sprinkler heads in all opened and although they held the fire in check it was necessary to use hose streams in order to extinguish it in these concealed spaces.

## 9. POINTS OF INTEREST FROM FIRE REPORTS.

### Automatic Sprinklers.

**S-14587.** Fire apparently started shortly after the shipper left the building in the early evening. Two sprinklers opened and entirely extinquished the fire. On account of the defective alarm valve no one learned of the operation of the sprinklers until the first employees to arrive in the morning, so that the sprinklers were discharging water at a pressure of thirty-five pounds for eight to ten hours. The fire loss was small but there was a considerable water loss.

The alarm valve which failed to operate was not of a type approved by the local board of underwriters.

**S-16873.** It is said that a passerby dropped a lighted match through a broken bull's-eye in the sidewalk and ignited waste paper in the basement. Thermostats and alarm valve both operated and upon the arrival of the fire department it was found that one sprinkler had opened and entirely extinguished the fire. The fire patrol shut the sprinkler valve in basement, replaced the fused head and again opened the valve, leaving the property under full sprinkler protection.

**This is a very good illustration of the efficiency of automatic sprinkler and alarm systems when properly maintained.**

**S-17740.** One sprinkler head operated for about an hour and a half, discharging some 6,000 gallons of water under 155 pounds pressure and entirely extinguished the fire. The valve controlling sprinkler heads in this area was located near engine room in basement with other control valves nearby. Delay in closing proper valve was responsible for the large quantity of water discharged through sprinkler. Had the watchman been familiar with the location of valves this delay would not have occurred.

**S-17449.** Two sprinklers operated for about twenty-five minutes discharging somewhat over 3,000 gallons of water under ninety pounds pressure and practically extinguished the fire. An unnecessary quantity of water was discharged owing to the fact that neither fire department nor fire patrol could locate the controlling valve.

**S-17521.** Fire originated from unknown cause in employee's clothing which hung under a stereotype storage rack. One sprinkler head operated and held the blaze in check but owing to a defect in the circuit closer the alarm valve failed to ring. The watchman upon seeing smoke went to the floor and broke open the door of the room in which the fire was burning. There was a loss of about $3,000 to stereotype plates.

### Use of Skids.

**S-17770.** The loss from this fire was only $131.60 due in large part to the fact that the stock was skidded four inches off the floors. It would have still further improved matters, however, if the floors had been sloped so as to drain rapidly.

**S-15837.** The large stock of valuable paper in cases was skidded from three to six inches and was further protected by a wrapping of waterproof paper. This was a decided factor in preventing a large damage from water.

### Fire Doors, Unprotected Openings.

**H-1768.** Standard sliding fire doors on one side of opening prevented fire from reaching adjoining composing room and office. They were a factor in saving the property from total destruction.

**H-4373.** The windows instead of being metal frame as they appeared, were of wooden frame, tin clad with the joints soldered to give a good appearance. The sill, top and sides of the window were also of the same construction. When the heat became intense the solder melted, allowing the joints in the tin to open. The tin was soon warped and the light wooden frame bent, the wired glass falling on the roof outside. These windows gave but little resistance to the fire.

**H-6164.** The elevator traps which were tin lined on the underside were very effective in stopping the fire from reaching floors below. There was considerable water loss.

**H-10489.** Fire spread so rapidly through elevator shaft and open stairway that employees had difficulty in getting out, many of whom were girls. Fortunately no one was severely injured. It was stated that the automatic traps on elevator failed to operate but sliding fire doors at openings in division walls operated and held the fire in check.

**H-6192.** Fire was discovered in the rear of the printing office on the first floor and was carried to the other floors through a small chute six by nine inches. Stairways were not enclosed and the fire followed these to the roof which was destroyed.

**H-9735.** Fire spread to the stairway through thin glass doors and into the hollow construction of stairway enclosure through to the roof. Properly enclosed vertical openings would probably have confined the fire to the floor of origin.

**H-10062.** Fire originated in the basement between the elevator and the stairway, probably from a cigarette butt. Fire spread quickly through elevator shafts which were protected by poorly fitting hatches and through open stairway on upper floor. Standard traps on the elevator and stairway would undoubtedly have checked the fire and prevented its reaching the upper floors.

### Miscellaneous.

**S-12378.** Much of this loss would doubtless have been saved had there been chemical extinguishers near at hand. A girl discovered the fire and called the foreman who tried to extinguish it with a broom. By the time the other employees came to his assistance with fire pails, the flames were beyond control.

## 10. EFFICIENCY OF WATER SUPPLIES TO SPRINKLER SYSTEMS.

| Primary Water Supply. | Number of fires | Per cent. of fires | Average pressure | Average number sprinklers opened | Number and Per Cent. of Fires. | | | | | | Average Pressure. | | | Average Number Sprinklers Opened. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Extinguished fire (or practically extinguished) | | Held fire in check | | Unsatisfactory | | Extinguished fire (or practically extinguished) | Held fire in check | Unsatisfactory | Extinguished fire (or practically extinguished) | Held fire in check |
| Water works, | 60 | 29.8 | 69 | 2.82 | 45 | 75.0 | 14 | 23.4 | 1 | 1.6 | 69 | 67 | 60 | 1.87 | 6.07 |
| Gravity tank, | 38 | 18.9 | 38 | 2.71 | 32 | 74.2 | 5 | 13.2 | 1 | 2.6 | 39 | 32 | 30 | 2.37 | 5.40 |
| Pressure tank, | 98 | 48.8 | 100 | 1.79 | 86 | 87.8 | 11 | 11.2 | 1 | 1.0 | 99 | 110 | 75 | 1.45 | 4.54 |
| Automatic pump, | 5 | 2.5 | 80 | 15.00 | 4 | 80.0 | 1 | 20.0 | .... | .... | 85 | 60 | .... | 5.00 | 55.00 |
| Total, | 201 | 100.0 | 78 | 2.63 | 167 | 83.1 | 31 | 15.4 | 3 | 1.5 | 79 | 76 | 55 | 1.83 | 7.00 |

## 11. EFFICIENCY OF WATER PRESSURES ON SPRINKLER SYSTEMS.

| Pressure on Sprinklers. | Number of fires | Per cent. of fires | Average pressure | Average number sprinklers opened | Number and Per Cent. of Fires. | | | | | | Average Pressure. | | | Average Number Sprinklers Opened. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Extinguished fire (or practically extinguished) | | Held fire in check | | Unsatisfactory | | Extinguished fire (or practically extinguished) | Held fire in check | Unsatisfactory | Extinguished fire (or practically extinguished) | Held fire in check |
| Less than 15 lbs., | 3 | 1.5 | 11 | 5.67 | 3 | 100.0 | .... | .... | .... | .... | 11 | .... | .... | 5.67 | ..... |
| 15 to 24 inclusive, | 4 | 2.0 | 20 | 1.50 | 3 | 75.0 | 1 | 25.0 | .... | .... | 20 | 23 | .... | 1.67 | 1.00 |
| 25 to 49 inclusive, | 36 | 17.9 | 36 | 2.74 | 28 | 77.8 | 7 | 19.4 | 1 | 2.8 | 37 | 35 | 30 | 2.29 | 4.57 |
| 50 and over, | 158 | 78.6 | 90 | 2.59 | 133 | 84.2 | 23 | 14.5 | 2 | 1.3 | 91 | 91 | 67 | 1.65 | 8.00 |
| Total, | 201 | 100.0 | 78 | 2.63 | 167 | 83.1 | 31 | 15.4 | 3 | 1.5 | 79 | 76 | 55 | 1.83 | 7.00 |

## 12. EFFICIENCY OF WET OR DRY SPRINKLER SYSTEMS.

| Wet or Dry System. | Number of fires | Per cent. of fires | Average pressure | Average number sprinklers opened | Number and Per Cent. of Fires. | | | | | | Average Pressure. | | | Average Number Sprinklers Opened. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Extinguished fire (or practically extinguished) | | Held fire in check | | Unsatisfactory | | Extinguished fire (or practically extinguished) | Held fire in check | Unsatisfactory | Extinguished fire (or practically extinguished) | Held fire in check |
| Wet system, | 192 | 95.5 | 77 | 2.33 | 161 | 83.9 | 29 | 15.1 | 2 | 1.0 | 78 | 76 | 45 | 1.76 | 5.52 |
| Dry system, | 9 | 4.5 | 98 | 9.87 | 6 | 66.7 | 2 | 22.2 | 1 | 11.1 | 109 | 75 | 75 | 3.67 | 28.50 |
| Total, | 201 | 100.0 | 78 | 2.63 | 167 | 83.1 | 31 | 15.4 | 3 | 1.5 | 79 | 76 | 55 | 1.83 | 7.00 |

## 13. EFFICIENCY OF WATER SUPPLIES TO SPRINKLER SYSTEMS —As Regards Amount of Loss.

| Primary Water Supply. | Number of fires | Per cent. of fires | Average pressure | Average number sprinklers opened | Number and Per Cent. of Fires. | | | | | | Average Pressure. | | | Average Number Sprinklers Opened. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | No claim | | Small loss | | Large loss | | No claim | Small loss | Large loss | No claim | Small loss | Large loss |
| Water works, | 60 | 29.8 | 69 | 2.82 | 9 | 15.0 | 46 | 76.7 | 5 | 8.3 | 72 | 69 | 55 | 1.12 | 1.78 | 15.60 |
| Gravity tank, | 38 | 18.9 | 38 | 2.71 | 18 | 47.4 | 19 | 50.0 | 1 | 2.6 | 42 | 34 | 30 | 2.72 | 2.84 | ..... |
| Pressure tank, | 98 | 48.8 | 100 | 1.79 | 27 | 27.6 | 68 | 69.3 | 3 | 3.1 | 107 | 102 | 68 | 1.22 | 2.00 | 3.00 |
| Automatic pump, | 5 | 2.5 | 80 | 15.00 | 2 | 40.0 | 2 | 40.0 | 1 | 20.0 | 105 | 65 | 60 | 8.00 | 2.00 | 55.00 |
| Total, | 201 | 100.0 | 78 | 2.63 | 56 | 27.9 | 135 | 67.2 | 10 | 4.9 | 81 | 79 | 57 | 1.95 | 2.05 | 17.40 |

## 14. EFFICIENCY OF WATER PRESSURES ON SPRINKLER SYSTEMS —As Regards Amount of Loss.

| Pressure on Sprinklers. | Number of fires | Per cent. of fires | Average pressure | Average number sprinklers opened | Number and Per Cent. of Fires. | | | | | | Average Pressure. | | | Average Number Sprinklers Opened. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | No claim | | Small loss | | Large loss | | No claim | Small loss | Large loss | No claim | Small loss | Large loss |
| Less than 15 lbs., | 3 | 1.5 | 11 | 5.67 | 1 | 33.4 | 2 | 66.6 | .... | .... | 13 | 10 | .... | 1.00 | 8.00 | ..... |
| 15 to 24 inclusive, | 4 | 2.0 | 20 | 1.50 | .... | .... | 4 | 100.0 | .... | .... | .... | 21 | .... | .... | 1.50 | ..... |
| 25 to 49 inclusive, | 36 | 17.9 | 36 | 2.74 | 12 | 33.3 | 20 | 55.6 | 4 | 11.1 | 36 | 37 | 36 | 3.58 | 2.35 | 2.00 |
| 50 and over, | 158 | 78.6 | 90 | 2.59 | 43 | 27.2 | 109 | 69.0 | 6 | 3.8 | 95 | 90 | 72 | 1.50 | 1.90 | 26.60 |
| Total, | 201 | 100.0 | 78 | 2.63 | 56 | 27.9 | 135 | 67.2 | 10 | 4.9 | 81 | 79 | 57 | 1.95 | 2.05 | 17.40 |

## 15. EFFICIENCY OF WET OR DRY SPRINKLER SYSTEMS —As Regards Amount of Loss.

| Wet or Dry System. | Number of fires | Per cent. of fires | Average pressure | Average number sprinklers opened | Number and Per Cent. of Fires. | | | | | | Average Pressure. | | | Average Number Sprinklers Opened. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | No claim | | Small loss | | Large loss | | No claim | Small loss | Large loss | No claim | Small loss | Large loss |
| Wet system, | 192 | 95.5 | 77 | 2.33 | 54 | 28.1 | 131 | 68.3 | 7 | 3.6 | 80 | 78 | 48 | 1.75 | 2.05 | 13.50 |
| Dry system, | 9 | 4.5 | 98 | 9.87 | 2 | 22.2 | 4 | 44.5 | 3 | 33.3 | 105 | 110 | 72 | 7.00 | 1.75 | 29.00 |
| Total, | 201 | 100.0 | 78 | 2.63 | 56 | 27.9 | 135 | 67.2 | 10 | 4.9 | 81 | 79 | 57 | 1.95 | 2.05 | 17.40 |

**Note**—"Average number of sprinklers opened" does not in any case include the Unsatisfactory fires.

# General Fire Record

## Unsatisfactory or Serious Fires in Buildings Equipped with Sprinklers.

**Where sprinklers fail the cause is, almost invariably, clear. These fires are selected to indicate such causes, that they may be generally understood and satisfactorily met.**

**S-18335. Saw Mill.** This plant of about 15,000 square feet area and of open joist construction, was used for wet log sawing. At the time of the fire the water was shut off the sprinkler system as a check valve was being installed on a new gravity tank or reservoir discharge pipe. The tank was empty and the pump shut off when the fire occurred, leaving both the hydrants and sprinklers entirely without water, although it is understood there was an arrangement whereby if certain valves on the underground mains were closed, the 500-gallon pump could be maintained constantly in service on the sprinklers and hydrants in the saw mill portion of the plant. The saw mill was practically destroyed with a loss of about $130,000. The dry kilns and lumber shed were saved due to the efficient work of employees with hose streams.

*Summary*: Water shut off.

**S-18413. Storage House of Cotton Mill.** This was a six-story and basement brick building, open finish, plank and timber floors, fire-resistive roof and cut-off stairs and elevators. Fire was discovered about 9 P. M. by the watchman who immediately rang a city fire alarm box. Additional alarms were turned in by the fire department so that at one time as many as twenty-two hose streams were being used. The private protection consisted of an approved automatic sprinkler system with a primary supply of twelve and eight-inch water mains with a pressure of sixty pounds; secondary supply consisted of steam and rotary pumps.

The storehouse was about 450 by 100 feet and was divided into six sections by fire walls. There were openings at each floor protected by fair two-inch non-standard fire doors. Fire started in the fifth section which was the second section from the easterly end used for the storage of cotton and finished cotton goods. It ate its way into the top section of No. 6, probably through the fire doors, and into the top story of section No. 4, a hot air explosion breaking the wall. It was several hours before the fire was controlled by the hose streams, the large pumps in the plant

furnishing several of these streams. As soon as possible the valves controlling the sprinklers in these sections were examined and it was found that the valves controlling sections 4, 5 and 6 were shut. This was the cause of the large loss. Seven thousand eight hundred and sixteen bales of cotton were either totally destroyed or damaged by smoke and water. There was also a considerable loss on finished cotton goods stored in the burned section. Fortunately there was very little wind so that the fire did not get beyond control or spread to the other buildings.

**Conclusions: Standard double fire doors should be installed at all important fire wall openings. Frequent expert examination should be made of all sprinkler system valves to insure their being in the proper position.**

*Summary*: Water shut off.

**S-18478. Storehouse.** This building had brick walls sixteen inches thick and a roof of plank on purlins on wood truss. It contained 6,564 bales of long fibre jute of about 400 pounds each. The jute was piled about 16 bales high on the side with a three-foot alley way in the middle and an eighteen-inch space near walls.

The fire was discovered by the first man who entered the building about five minutes before the opening hour in the morning. He ran for assistance and an attempt was made to extinguish the fire with water pails but as these were insufficient the mill fire brigade used hose streams from yard hydrants and were finally reinforced by the public fire department. In about four hours the jute piles had become so swollen by the water thrown upon the fire that their expansion was sufficient to push out about one-half of the north, east and west walls so as to let down the roof in this quarter, and a three-inch sprinkler pipe was broken off. This made it necessary to shut off the sprinklers. By that time the fire was well under control and was finally extinguished with five hose streams but not until practically all of the stock in the building had been thoroughly soaked with water. The building itself was not damaged directly by fire. A recently installed meter on the fire service connection showed that 187,000 gallons of water were used. Twenty-six sprinkler heads operated at a pressure of approximately sixty pounds. Their failure to control the fire was due to the fact that the stock was piled so high that the water could not reach the seat of the fire. There was a loss of $40,000 to $50,000.

*Summary*: Obstruction to distribution.

# Points of Interest from Fire Reports.

These notes are intended to illustrate the efficiency or inefficiency of signaling, retardant or extinguishing agencies.

## Extinguishers.

**S-18345. Garage.** Back fire of automobile caused the ignition of gasoline from a leaky connection to the engine. Fire was extinguished by employees with three hand chemical extinguishers. No sprinklers operated.

**S-18120.** Fire occurred in the motor operating elevator machinery. It was promptly discovered and put out by employees with extinguishers of the carbon tetrachloride type and sand pails. No sprinklers operated.

**H-11310. Metal Worker.** Fire was noticed in the conveyor motor in the pent house on top of one of the cylindrical steel ore bins. The mill fire brigade first used extinguishers of the carbon tetrachloride type. About twenty of these were used without effect and the fire was finally put out by a large hose stream which was pulled up the spiral stairway.

**S-18326. Automobile Service Station.** Employees were repairing a leaky connection to gasoline tank in automobile and evidently struck a spark or crossed wires with the tools they were using so that the gasoline vapor ignited. Employees rang in public fire alarm box and started to use some extinguishers of the carbon tetrachloride type. As the liquid from these extinguishers was played into the flames a chlorine gas was given off which practically drove the men away from the automobile. Three sprinkler heads opened and held the fire in check until the arrival of the fire department.

## Automatic Sprinklers.

**H-11263. Moving Picture Theatre.** An operator was rewinding a reel of film when it became ignited from unknown cause. There was another reel exposed on the rewinding shelf which was also consumed. The automatic sprinkler in the booth operated and finally extinguished the flames without loss to the building or contents other than the destruction of these two films.

**S-18429. Sulphite Pulp and Paper Mill.** Fire was discovered in a corner of the basement near the wood chipping machine and probably resulted from a spark in this machine which in turn ignited the fine dust in the air. On account of the large accumulation of fine dust in the wood room building a flash fire resulted which spread with such rapidity that the men employed in this building barely had opportunity to escape. The fire extended up the conveyor line into chip bins and by this time the sprinklers had opened and were very effective in holding it in check, the blaze being finally extinguished by hose streams.

The two following points with reference to the sprinkler equipment would seem worthy of note: (1) Small feed line to sprinklers was completely severed in two places with clean breaks, probably due to the difference in temperature between the cold water circulating through the pipes and the sudden intense heat developing in this section of the building; (2) approximately one-half hour from the time fire began, the beams supporting the two three-and-one-half-inch sprinkler risers had burned sufficiently to allow these risers to drop and break. Fortunately the fire was under such control at this time that their failure was not a factor. The very prompt and effective operation of the sprinklers probably prevented a total loss. The sound value of the property was about $100,000 and there was a loss of $18,000.

**S-18448. Paint Mixing and Grinding Works.** This fire probably was caused by spontaneous combustion of oily waste carelessly left out of the metal can provided for its safe keeping. The fire occurred in a very hazardous portion of the plant as several barrels of oil and varnish were stored within a few feet of where it originated. The prompt action of one sprinkler head extinguished the fire before there was any loss.

### Sprinkler Alarms.

**S-18327.** An examination of the rotary gong which failed to operate showed that the clapper was so badly worn and battered as to lock (when the clapper rested on the gong face) so securely that a hammer or lever was necessary to start it. Since this system was installed in May, 1915, this defect is apparently chargeable to the firm supplying the equipment.

**S-18319. Tenant Manufacturing — Clothing.** Three sprinkler heads operated for about fifty minutes, discharging approximately 6000 gallons of water. Had the sprinkler system been equipped with a central station alarm service or had there been watchman service, this loss would probably have been considerably less.

### Pumps.

**H-10842.** Fire occurred in a two-story brick building of open construction used for a paper mill. The fire pump was started and two streams were used, but the pump was soon made inoperative owing to the

falling of the roof of the finishing building onto the roof of the machine building directly over the fire pump.

**Fire pumps should be located in readily accessible places and, in so far as possible, in parts of the building which are the least liable to suffer by fire.**

### Miscellaneous.

**H-11322.** Frame building which was formerly used as a residence had been converted into a hospital and home for the county poor. The building did not contain any fire appliances, and when an employee discovered a fire in the kitchen he was unable to do anything towards extinguishing it. The building burned with great rapidity and within thirty minutes it completely collapsed. One of the nurses was badly burned in attempting to rescue a patient; another employee suffered from a broken leg; and one of the patients died from heart failure which was probably brought about by the fire.

**The practice of utilizing all kinds of buildings, both good and bad, for hospitals is quite common. The danger to helpless patients in case of fire should be carefully considered and the continued use of fire traps unsparingly condemned.**